L H Moon
& Son
Bookbinders

NATIONAL MUSEUM OF VICTORIA

RECORDS

OF THE

AUSTRALIAN MUSEUM

VOL. 28

PRINTED BY ORDER OF THE TRUSTEES

SYDNEY, 1970–1973

CONTENTS

No. 1

Published 26th March, 1970

PAGE

Structural Composition and Dental Variations in the Murids of the Broom Cave Fauna, Late Pleistocene, Wombeyan Caves Area, N.S.W., Australia. By Frederick R. Schram and William D. Turnbull 1

No. 2

Published 27th August, 1970

Results of an Archaeological Survey of the Hunter River Valley, New South Wales, Australia. Part I: The Bondaian Industry of the Upper Hunter and Goulburn River Valleys. By David R. Moore 25

No. 3

Published 29th September, 1970

The Genus *Chlorinoides* (Crustacea, Brachyura, Majidae). 2. *Chlorinoides Goldsboroughi* Rathbun from Eastern Australia, *C. Tenuirostris* Haswell and a New Species from Western Australia. By D. J. G. Griffin 65

No. 4

Published 20th November, 1970

Two New Stomatopod Crustaceans from Australia. By Raymond B. Manning 77

No. 5

Published 26th August, 1971

Intertidal Alcyonarians in the vicinity of Darwin, Northern Territory, Australia. By Huzio Utinomi 87

No. 6

Published 27th September, 1971

A new species of *Kelleria* (Copepoda: Cyclopoida) from Brackish Water in Victoria. By I. A. E. Bayly 111

No. 7

Published 4th October, 1971

PAGE

Balls Head: The Excavation of a Port Jackson Rock Shelter. By Sandra Bowdler 117

No. 8

Published 25th January, 1972

Bassianobdella fusca sp. nov. (Hirudinoidea: Richardsonianidae), with an Initial Demonstration of Systematic Values in the Lengths of Annuli in the Mid-Nephric Somites. By Laurence R. Richardson 129

No. 9

Published 2nd February, 1972

Australasian *Pectiniseta* Stein, with Notes on the Genus (Diptera, Muscidae). By Adrian C. Pont 141

No. 10

Published 10th December, 1972

Maori Greenstone Pendants in the Australian Museum, Sydney. By D. Wayne Orchiston 161

No. 11

Published 12th January, 1973

Earthworms (Megascolecidae: Oligochaeta) from Mount Kosciusko, Australia. By B. G. M. Jamieson 215

No. 12

Published 24th January, 1973

Typton australis sp. nov., A. New Pontoniinid Shrimp from the Great Barrier Reef, Australia. By A. J. Bruce 253

No. 13

Published 2nd February, 1973

A New Species of *Notuchus* (Homoptera, Fulgoroidea, Delphacidae) from Lord Howe Island. By R. G. Fennah 265

No. 14

Published 13th February, 1973

PAGE

Galatheidea (Crustacea, Decapoda, Anomura) Collected by the F.I.S. Endeavour. By Janet Haig 269

No. 15

Published 5th July, 1973

The Alpheid Shrimp of Australia. Part 1: The Lower Genera. By Dora M. and Albert H. Banner 291

No. 16

Published 13th July, 1973

Nelima doriae (Canestrini), a South European Harvestman in Australia and New Zealand (Arachnida, Opiliones, Phalangiidae). By Jürgen Gruber and Glenn S. Hunt 383

No. 17

Published 20th July, 1973

The Harpacticoid Copepods (Crustacea) of the Saline Lakes in Southeast Australia, with Special Reference to the Laophontidae. By R. Hamond 393

No. 18

Published 3rd August, 1973

The Australian Species of Robertsonia (Crustacea, Harpacticoida), with a Revised Key to the Genus. By R. Hamond 421

No. 19

Published 10th December, 1973

Broom Cave *Cercartetus*, with Observations on Pygmy Possum Dental Morphology, Variation and Taxonomy. By William D. Turnbull and Frederick R. Schram 437

CONTRIBUTORS

PAGE

BANNER, DORA M. and ALBERT H.

The Alpheid Shrimp of Australia. Part 1: The Lower Genera 291

BAYLY, I. A. E.

A New Species of Kelleria (Copepoda: Cyclopoida) from Brackish Water in Victoria 111

BOWDLER, SANDRA

Balls Head: The Excavation of a Port Jackson Rock Shelter 117

BRUCE, A. J.

Typton australis sp. nov., A New Pontoniinid Shrimp from the Great Barrier Reef, Australia 253

FENNAH, R. G.

A New Species of *Notuchus* (Homoptera, Fulgoroidea, Delphacidae) from Lord Howe Island 265

GRIFFIN, D. J. G.

The Genus *Chlorinoides* (Crustacea, Brachyura, Majidae). 2. *Chlorinoides goldsboroughi* Rathbun from Eastern Australia, *C. tenuirostris* Haswell and a New Species from Western Australia 65

GRUBER, JURGEN and HUNT, GLENN S.

Nelima doriae (Canestrini), A South European Harvestman in Australia and New Zealand (Arachnida, Opiliones, Phalangiidae) .. 383

HAIG, JANET

Galatheidea (Crustacea, Decapoda, Anomura). Collected by the F.I.S. *Endeavour* 269

HAMOND, R.

The Harpacticoid Copepods (Crustacea) of the Saline Lakes in Southeast Australia, with Special Reference to the Laophontidae 393

HAMOND, R.

The Australian Species of Robertsonia (Crustacea, Harpacticoida), with a Revised Key to the Genus 421

HUNT, GLENN S., and GRUBER, JURGEN

Nelima doriae (Canestrini), a South European Harvestman in Australia and New Zealand (Arachnida, Opiliones, Phalangiidae) .. 383

CONTRIBUTORS—*continued*

PAGE

JAMIESON, B. G. M.

Earthworms (Megascolecidae: Oligochaeta) from Mount Kosciusko, Australia 215

MANNING, RAYMOND B.

Two New Stomatopod Crustaceans from Australia 77

MOORE, DAVID R.

Results of an Archaeological Survey of the Hunter River Valley, New South Wales, Australia. Part 1: The Bondaian Industry of the Upper Hunter and Goulburn River Valleys 25

ORCHISTON, D. WAYNE

Maori Greenstone Pendants in the Australian Museum, Sydney 161

PONT, ADRIAN C.

Australasian Pectiniseta Stein, with Notes on the Genus (Diptera, Muscidae) 141

RICHARDSON, LAURENCE R.

Bassianobdella fusca sp. nov. (Hirudinoidea: Richardsonianidae), with an Initial Demonstration of Systematic Values in the Lengths of Annuli in the Mid-Nephric Somites 129

SCHRAM, FREDERICK R., and TURNBULL, WILLIAM D.

Structural Composition and Dental Variations in the Murids of the Broom Cave Fauna, Late Pleistocene, Wombeyan Caves Area, N.S.W., Australia 1

SCHRAM, FREDERICK R., and TURNBULL, WILLIAM D.

Broom Cave *Cercartetus,* with Observations on Pygmy Possum Dental Morphology, Variation, and Taxonomy 437

TURNBULL, WILLIAM D., and SCHRAM, FREDERICK R.

Structural Composition and Dental Variations in the Murids of the Broom Cave Fauna, Late Pleistocene, Wombeyan Caves Area, N.S.W., Australia 1

TURNBULL, WILLIAM D., and SCHRAM, FREDERICK R.

Broom Cave *Cercartetus,* with Observations on Pygmy Possum Dental Morphology, Variation, and Taxonomy 437

UTINOMI, HUZIO

Intertidal Alcyonarians in the Vicinity of Darwin, Northern Territory, Australia 87

60110 10.73 V. C. N. BLIGHT, GOVERNMENT PRINTER

Structural Composition and Dental Variations in the Murids of the Broom Cave Fauna, late Pleistocene, Wombeyan Caves Area, N.S.W., Australia

By FREDERICK R. SCHRAM, Walker Museum, University of Chicago, U.S.A., and
WILLIAM D. TURNBULL, Field Museum of Natural History, Chicago

This study is based on materials procured by William D. Turnbull and E. L. Lundelius Jr (University of Texas) and prepared by the authors with National Science Foundation assistance (Grants GB975 and GB3729)

Plates 1-3. Figures 1-5. Manuscript received, 20th July, 1967.

INTRODUCTION

Robert Broom (1895 a & b, 1896) described several marsupials from a Late Pleistocene bone breccia of the Wombeyan Caves area near Taralga, New South Wales, Australia. W. D. L. Ride (1956 a & b, 1960) treated Broom's fauna more completely. He described a new species of the murid genus *Mastacomys*, recorded two other rodents, and analysed the faunal constitution of the breccia based on a sample of "nine large pieces" of this formation from the Broom collection in the Anatomical Museum at Edinburgh. He designated the fossils from this locality the Broom Cave Fauna.

In 1964, one of us (W.D.T.) arranged with H. O. Fletcher (Deputy Director, Australian Museum) for the loan of an unprepared collection of 189 pieces of this Wombeyan Cave bone breccia. This collection was made by Mr Fletcher several years ago and he kindly offered to share any specimens obtained from these blocks with the Field Museum, if we, in turn, would prepare and study the material. For the past 2 years we have done this. We wish to thank Mr Fletcher and the Australian Museum for generously making these materials available.

Acid treatment of the first 44 of these blocks has produced sufficient material for an analysis of the murid element of this fauna. Nearly 300 specimens of maxillae, rami, and individual cheek teeth were obtained, containing a total of 372 teeth.

There are four rodent taxa in the sample: *Pseudomys oralis*, *Gyomys glaucus*, *Mastacomys wombeyensis*, all recorded by Ride, and *Rattus* sp., a new record. Age distributions and estimations of numbers of individuals present in the sample along with variations in dental characters are noted.

This report is the first of a planned series that will be presented as the preparation and study of the Fletcher collection continues. Only the murid species are considered in this paper.

Rec. Aust. Mus. **28**, page 1.

METHODS AND PROCEDURES

Preparation Methods

The breccia pieces, ranging in weight from a few ounces to about 4 pounds, were broken down with 10 per cent acetic acid to free the contained bones and teeth. This acid concentration was found to be ideal, for at this strength the bone is least affected and the matrix is readily attacked. Stronger concentrations hazard the bone to a far greater extent, and require much more effort in periodically impregnating the newly exposed bone with an impervious plastic to prevent its destruction along with the matrix. A detailed discussion of the preparation methods was given by Ride (1956a). Even after this weak acid treatment the small, loose, individual bones and teeth are very fragile. A thin solution of methyl methacrylate ("plexiglass" or "perspex") dissolved in ethylene dichloride (Ride, 1956a) was used to impregnate and strengthen them for pin-mounting within gelatine capsules for protection and ease of handling.

Initially each matrix block was lettered for identification. As the acid treatment progressed, frequent examinations were made to note articulations and/or associations of elements as they appeared. All materials from a single block of breccia were segregated, recorded, and distinguished according to the block of origin so that undetected associations might be made later.

Ride (1960, pp. 76–77) concluded that the Broom Cave Fauna was largely the result of an owl pellet accumulation. We concur in this and, in addition to the sort of evidence set forth by Ride, we have also observed, as acid treatment progressed, many pellet-like aggregations of bones. Since recent owl pellets are typically very fragile objects, such intact pellet-like structures suggest that there was only a limited amount of sorting and redeposition prior to cementation of the breccia. Accordingly, in a few instances, we stopped the acid treatment and set aside examples of these aggregations for the record and future study.

Study Methods and Procedures

The methods of study require some detailed comment.

First, since we are working with fragmentary materials (mostly, but not entirely, with isolated teeth and bones), care has been taken to distinguish between numbers of teeth, numbers of specimens, and estimates of numbers of individuals. In so doing cognizance is taken of known correlations and/or positive associations. In most instances this involves correlations within molar quadrants. In the case of *Mastacomys*, in which we have two essentially complete palates, it also involves correlations between quadrants.

Second, an attempt has been made to separate clearly three related kinds of statements: (1) those pertaining to our sample and its associated statistics; (2) those that draw inferences from this sample concerning the peculiar nature of the burial assemblage that it was drawn from (an owl pellet accumulation); and (3) those that in turn make inferences about the original population.

In dealing with the sample, we encounter a problem which frequently plagues paleontologists and archaeologists. Most neozoological samples are drawn *directly* from a fauna, and hence the sample is of a *known* size, i.e., a definite number of individuals (N). With fragmentary fossil materials, however, the actual size of a sample, i.e., the number of individuals the sample represents, is often quite uncertain. In such cases, for purposes of comparisons within the fauna the absolute minimum number of individuals that could have contributed to the sample is often used because it is easy to derive. But it is difficult to compare directly modern samples of a known N and those fossil samples for which only the absolute minimum of specimens is available, although relative comparisons may have meaning.

Assessment of the absolute minimum number of individuals comprising a sample is usually based on the largest number of specimens of any single element contained in the sample such as L.$M^{\underline{1}}$ or R.$M_{\overline{3}}$, or if more than dental and cranial elements are being considered, L. calcanea, or R. femora, etc. This is done by taking the element represented by the greatest number of specimens to indicate the very least number of individuals present. If, for example, a collection contained specimens as follows: 15 R.$M^{\underline{1}}$, 13 R.$M^{\underline{2}}$, 20 L.$M^{\underline{3}}$, 17 R.$M_{\overline{3}}$, and 14 L.$M_{\overline{1}}$ of "species X", then this collection must represent at least 20 individuals. When dental remains are involved, it is often possible to refine the assessment of the minimum number by taking account of the age spread of the sample as is indicated by tooth wear. In our samples, to do this the five age grades used by Ride (1956a, p. 433) were employed: "(a) distinct cusps on all molars, (b) wear beginning to unite cusps into laminae, (c) all cusps united transversley but cusps still discernible, (d) cusps no longer discernible, (e) laminae themselves disappearing". If all the teeth are arranged tabularly (appendix) and numbers of teeth in each age group are noted, then the most frequently represented tooth in an age category gives the minimum number of individuals at that age stage. For example (appendix table 1) in *Gyomys glaucus* the most frequently represented tooth at wear stage "a" is the R.$M^{\underline{1}}$ with two teeth; for wear stage "b" it is the L.$M_{\overline{2}}$ with eight; for "c" it is R.$M^{\underline{1}}$ (or $M^{\underline{2}}$) with eleven; etc. The total of these most frequently represented teeth from all age categories (shown in next to the bottom row of the table) gives the "age spread" minimum number of individuals in the sample. In this example we obtain 32 individuals as opposed to 23 as assessed by the traditional method. This age spread method is basically identical with the traditional method, except that the sample is first broken into age groups.

In order to arrive at an estimate of the actual size of a sample that is comprised largely (or entirely) of very fragmentary materials, a means of confining and restricting the spread between the assessments of maximum and minimum numbers of individuals must be found (see fig. 1). The age spread minimum number appears to be an adequate restricting parameter for the low end of the scale, but the upper end has usually been more troublesome to deal with. Before a more realistic estimate of sample size can be achieved, a similar means of restricting the maximum must be found.

It is easy to assess the absolute maximum number of individuals that could be represented by a sample on the assumption that each uncorrelated tooth represents a different individual. (For this sample of *G. glaucus* we get 166 individuals.) This is not very helpful, for it provides only an outside, and not very narrowly restricting value for the upper end of the scale. Also, under many depositional situations relating to the burial assemblage from which a sample might be drawn, one would expect some overlap of the isolated teeth whereby some would be from individuals already represented by other teeth. Thus, unfortunately, there does not appear to be a universal means of judging the reasonableness of the basic assumption in most instances. An owl pellet accumulation offers a notable exception, however—and as a general rule the less disturbed the accumulation, the more striking is the exception. Regurgitated pellets contain, in addition to (and among) the hair and other indigestibles, more or less associated skeletal remains of the victims of each separate feeding by the owl. Most of the minor separation of elements that were originally contained within the pellet (i.e., that which occurs subsequent to regurgitation and initial deposition) must result from natural organic breakdown and mixing from such causes as drying, bacterial action, and the activity of invertebrate scavengers. This type of activity more easily moves small objects such as individual teeth, than larger ones such as jaw rami, maxillaries or whole skulls. If intact pellets are present (as appears to be the case for the Broom Cave) then the possibility of larger scale redeposition is ruled out. Thus in this sort of deposit we can be reasonably certain of a high degree of inter-correlation among specimens with respect to numbers of individuals—so high as to favour the use of an estimate based upon the assumption of almost full correlation. This we call the "minimal estimate" of the maximum number of individuals which could be represented in the sample.

The method of obtaining this minimal estimate of the maximum number involves age spreading, as with the age spread minimum. Here, however, the number of *specimens* in the largest suite of teeth likely to have been preserved as a unit is employed, instead of individual teeth. This suite is taken to be a molar row; left or right, upper or lower. The number of specimens represented by four molar quadrants is thus determined instead of dealing with the numbers of twelve different teeth as in the minimum number assessment.

The tables in the appendix record by age group both numbers of teeth (first column) and numbers of specimens for the molar quadrants (second column). For example, in *G. glaucus* the 31 teeth in the right upper molar quadrant at wear stage "c" (11, 11, and 9), are in 25 specimens. These 25 specimens could represent as many as 25 individuals if no correlations among the teeth exist other than those that were observed, or as few as eleven if full correlation were the case.

As suggested above, the chance of post-regurgitation movements of small individual teeth either into or out of the immediate area of a pellet is quite good, and is very much more likely than a comparable shifting of larger objects such as rami or maxillae (molar quadrants). Hence, correlation of loose teeth should be low while that of molar quadrants should be high. Since we are searching for a minimal estimate of the *maximum number* of individuals we assume we found most of the correlations for the loose teeth and that the estimate of the maximum number of 25 individuals is reasonably realistic for those 25 specimens comprising 31 teeth. To make the estimate *minimal* for this maximum number, we next assumed nearly full correlation between the specimens (quadrants) represented. The bottom row of the table gives the tally for the maximum number of specimens by molar quadrant for the age groups, which total is our minimal estimate of the maximum number of individuals represented in the sample—in this case 53.

These estimates serve to place limits on the size of the sample (fig. 1). For instance, for *G. glaucus*, which is represented in this sample by 209 teeth in 166 specimens, the absolute maximum and minimum limits on numbers of individuals are 166 and 32 respectively. As has been explained, 53, the minimal estimate of the maximum number of individuals represented, is *probably* a fairly close assessment of the actual number of individuals comprising the sample in this special case.

Teeth were measured either with an ocular micrometer or vernier caliper. Where justified, mean, standard deviation, and coefficient of variation were calculated. Observations on the gross morphologic variations in cusp pattern and arrangement were made. Abbreviations used for specimens are as follows: F — Australian Museum; AMEU — Anatomical Museum of Edinburgh University; BM — British Museum (Nat. Hist.); and PM, which is a prefix for some of the fossil mammal collections of the Field Museum; unprefixed number refers to a specimen in the recent mammal collection of the Field Museum. A specimen listing of all materials of the Broom Cave fauna used in this work is given in the appendix.

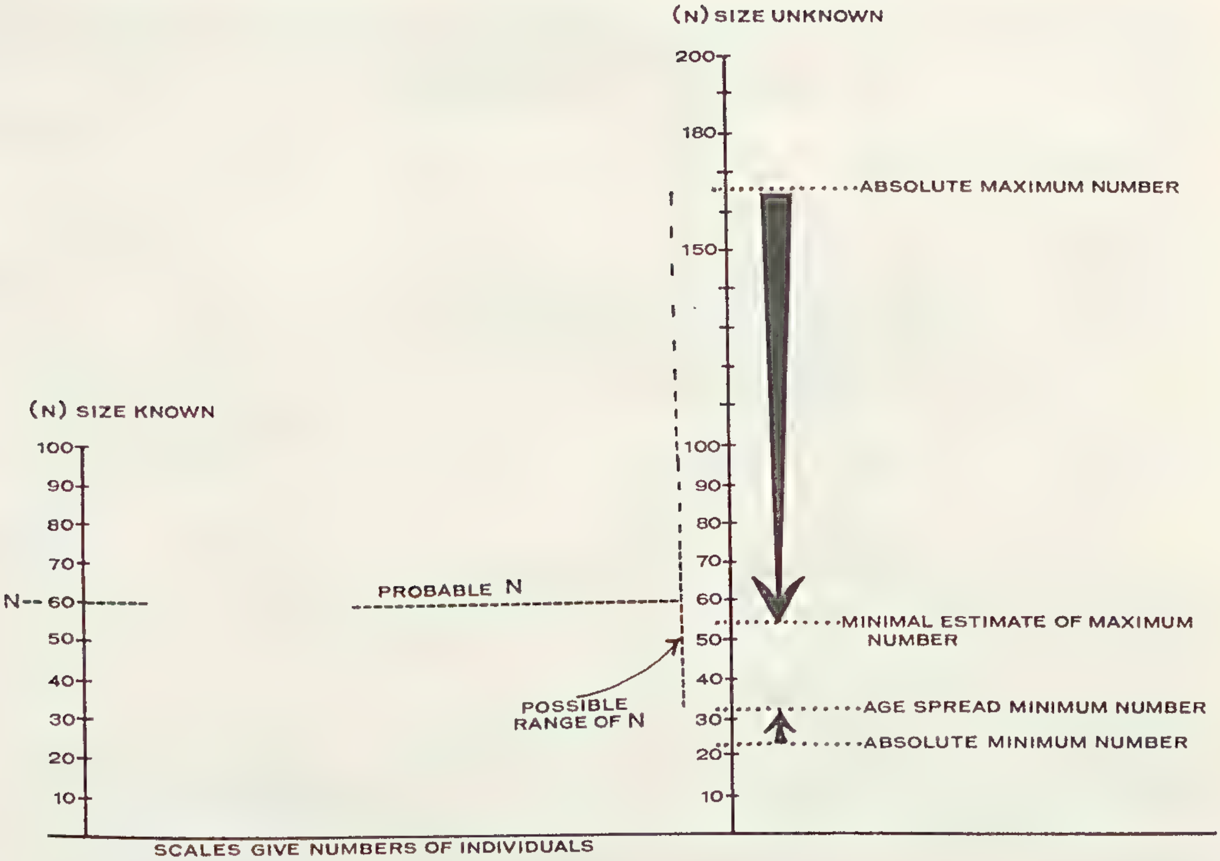


Figure 1.—Comparisons of a standard modern biological sample (left) with a sample comprised of fragmentary fossils (right). In the standard sample, which is usually drawn directly from a living population, sample size (N) is an exact, known number of individuals. For a sample of fragmentary fossils drawn from a burial assemblage, and not directly from a living population, N is usually unknown. The absolute maximum and minimum numbers of individuals that could comprise the sample can be determined, but such limits to the possible range of sample size are usually not restrictive enough to make the samples comparable to standard samples. Variations in wear of teeth often provide a better means of determining the minimum number of individuals (age-spread min.), but no satisfactory means of further restricting the upper end of the scale has existed (arrows). With undisturbed owl pellet accumulations, where theoretically the minimal estimate of the maximum number of individuals should approximate the true N closely (see text), we do have a means of achieving a restriction of the possible range of estimates. Data for this example are for *Gyomys glaucus* from text table 1 and appendix table 1, for which a value for N of about 60 appears probable.

RESULTS AND DISCUSSION

The relative abundance of each murid in the sample according to various estimates discussed above, is set forth in table 1. By any of these standards *Pseudomys oralis* and *Gyomys glaucus* are seen to have been the common rodents and *Mastacomys wombeyensis* and *Rattus* sp. were scarce. It is therefore not surprising that the earlier, smaller samplings of the fauna did not turn up a single *Rattus* tooth, and only yielded one specimen of *M. wombeyensis*.

The bivariate scatter diagrams for the M^2's of the Broom Cave murids (fig. 2) reflects this relative abundance, and shows other features such as size, proportions, and variability for *P. oralis* (table 4) and *G. glaucus* (table 5) for which there are fair-sized samples. For *Rattus* sp. and *M. wombeyensis*, the materials are still too inadequate to do more than give crude approximations of these features.

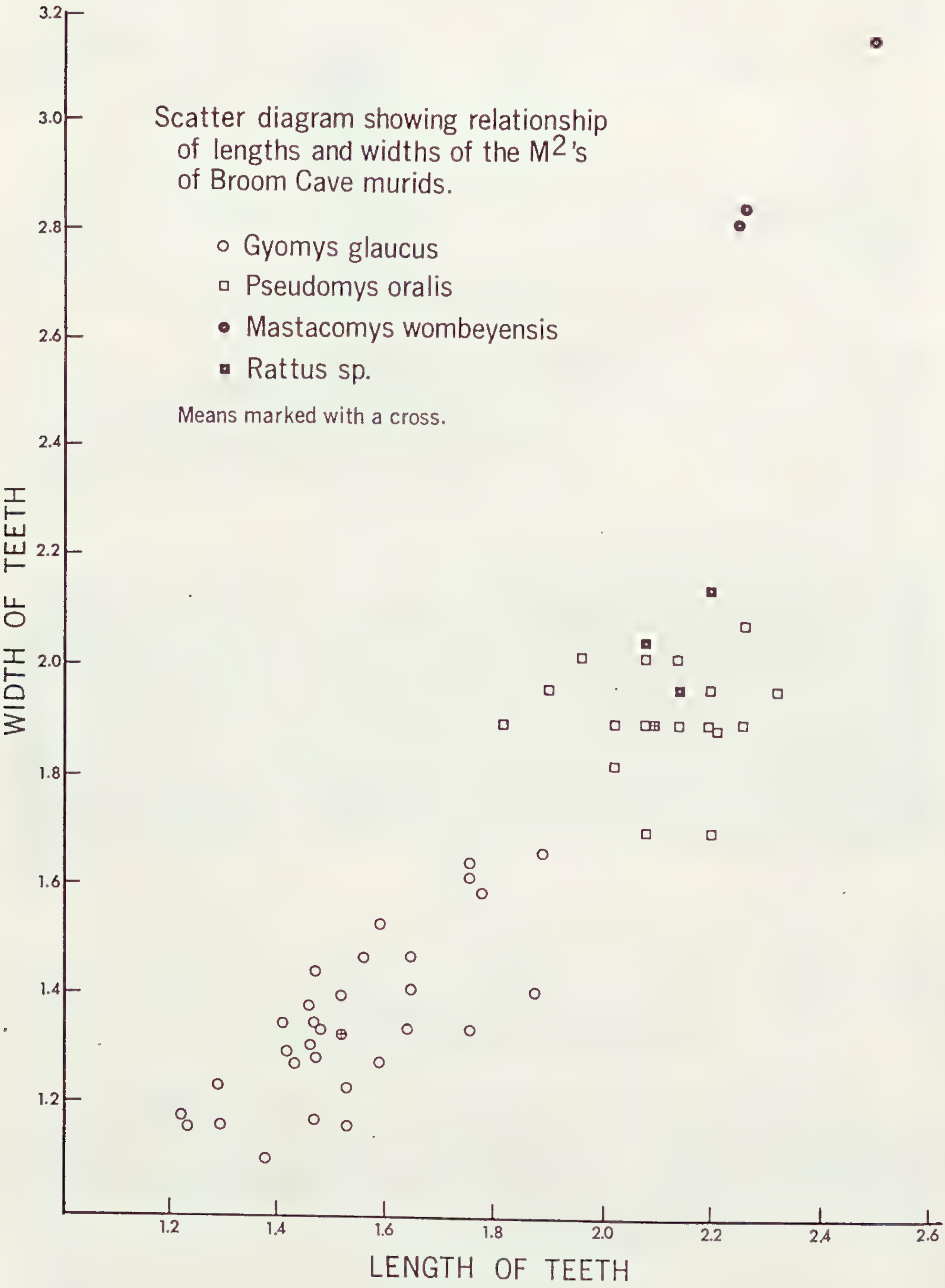


Figure 2

Table 1. Relative abundance of murids in the sample of the Broom Cave fauna

Species	Number of teeth	Minimum number individuals		Estimates of maximum numbers of individuals	
		Traditional	Age spread	Minimal estimate	Absolute maximum number (number of specs)
Mastacomys wombeyensis Ride	23	4	5	6	12
Pseudomys oralis Thomas	130	18	24	40	97
Gyomys glaucus Thomas	209	23	32	53	166
Rattus sp.	6	2	4	4	5

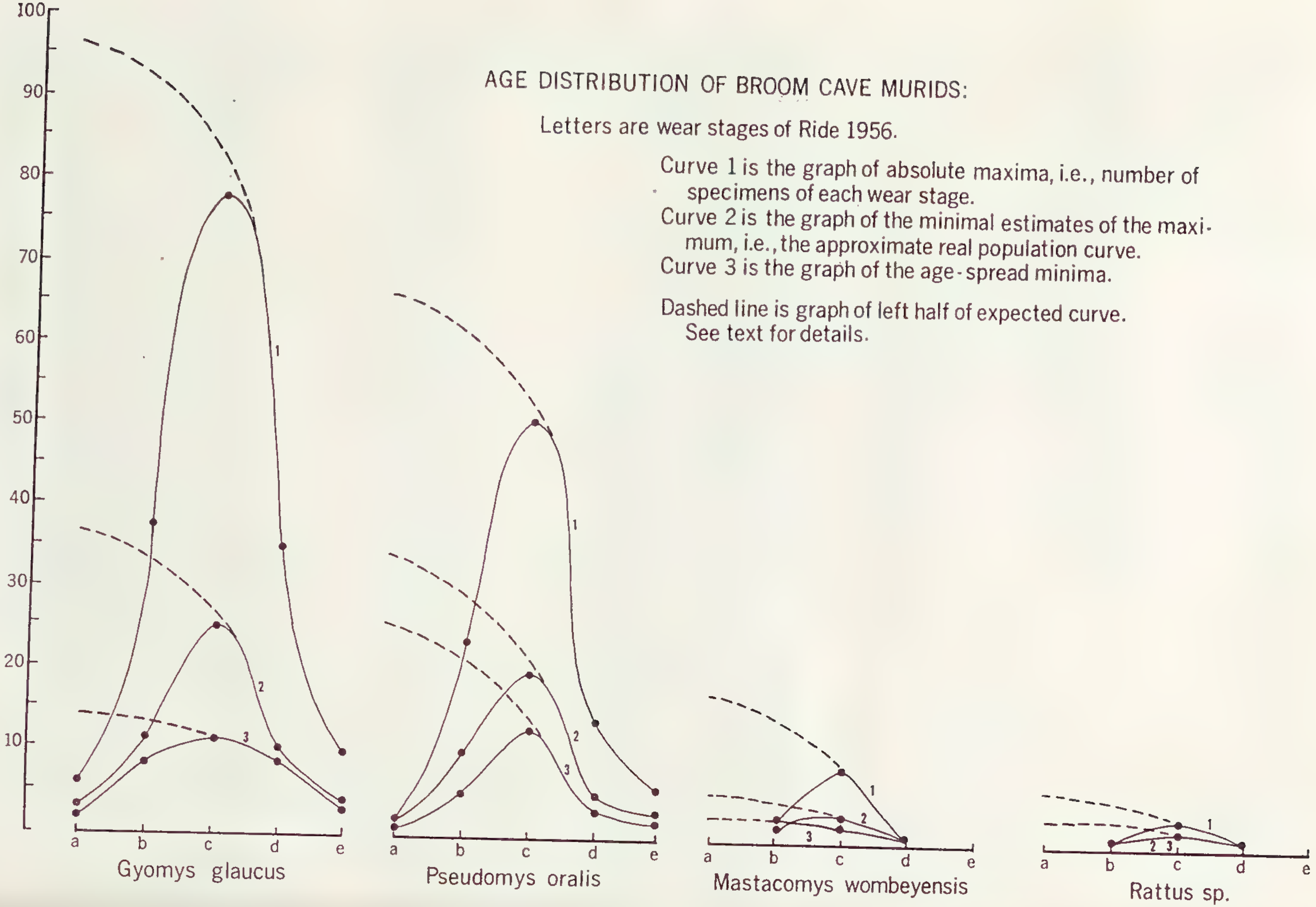
Age distributions of the specimens upon which table 1 was based are given in figure 3. In each case a bell-shaped curve is seen, regardless of the method of population estimation used. If owls are approximately indiscriminate in capturing rodents, the expected distributions should be some sort of survivorship curves, perhaps more like those expressed by the combination curves made up of the dotted lines and the right sides of the bell curves. The deficiencies in numbers of young animals must result from their being in the nest, where they are largely freed from owl predation. The bell curve is then a picture of the part of the population that is actually roaming about when and where the owls could capture them.

Morphology

Our materials are adequate for some detailed considerations of tooth morphology. The dental terminology of Hershkovitz (1962) is used rather than simple numbering of cusps and styles such as that used by Ellerman (1941) or Ride (1960), (see figure 4). Tables 2 through 6 give measurements for the Australian Museum and Field Museum specimens and repeat certain measurements from other sources.

Mastacomys wombeyensis Ride 1956

We have no basis for judging the value of one of Ride's diagnostic characters, zygomatic plate width (actually zygomatic plate length), but merely give its measurement for F52303. The M^3 carries the other diagnostic character of this species, the lateral accessory cusp noted by Ride. It is located between the second and third laminae on the lingual side. We designate this structure an enterostyle (plate 1, e and f). All the upper molars have a characteristic great width in this genus. As is generally the case with the older endemic Australian murids (see p. 13), the labial elements of M^1, i.e., the anterolabial style and the mesostyle, show atrophy. There is no indication of the anteromedian style which is sometimes present in the *Pseudomys* group of murids. The diagnostic enterostylar character appears to be a valid one, relieving somewhat Ride's (and our) reservations. Out of 12 specimens assignable to this species only three M^3's are present but all three show a developed enterostyle.



AGE DISTRIBUTION OF BROOM CAVE MURIDS:

Letters are wear stages of Ride 1956.

Curve 1 is the graph of absolute maxima, i.e., number of specimens of each wear stage.
Curve 2 is the graph of the minimal estimates of the maximum, i.e., the approximate real population curve.
Curve 3 is the graph of the age-spread minima.

Dashed line is graph of left half of expected curve. See text for details.

Gyomys glaucus

Pseudomys oralis

Mastacomys wombeyensis

Rattus sp.

Figure 3

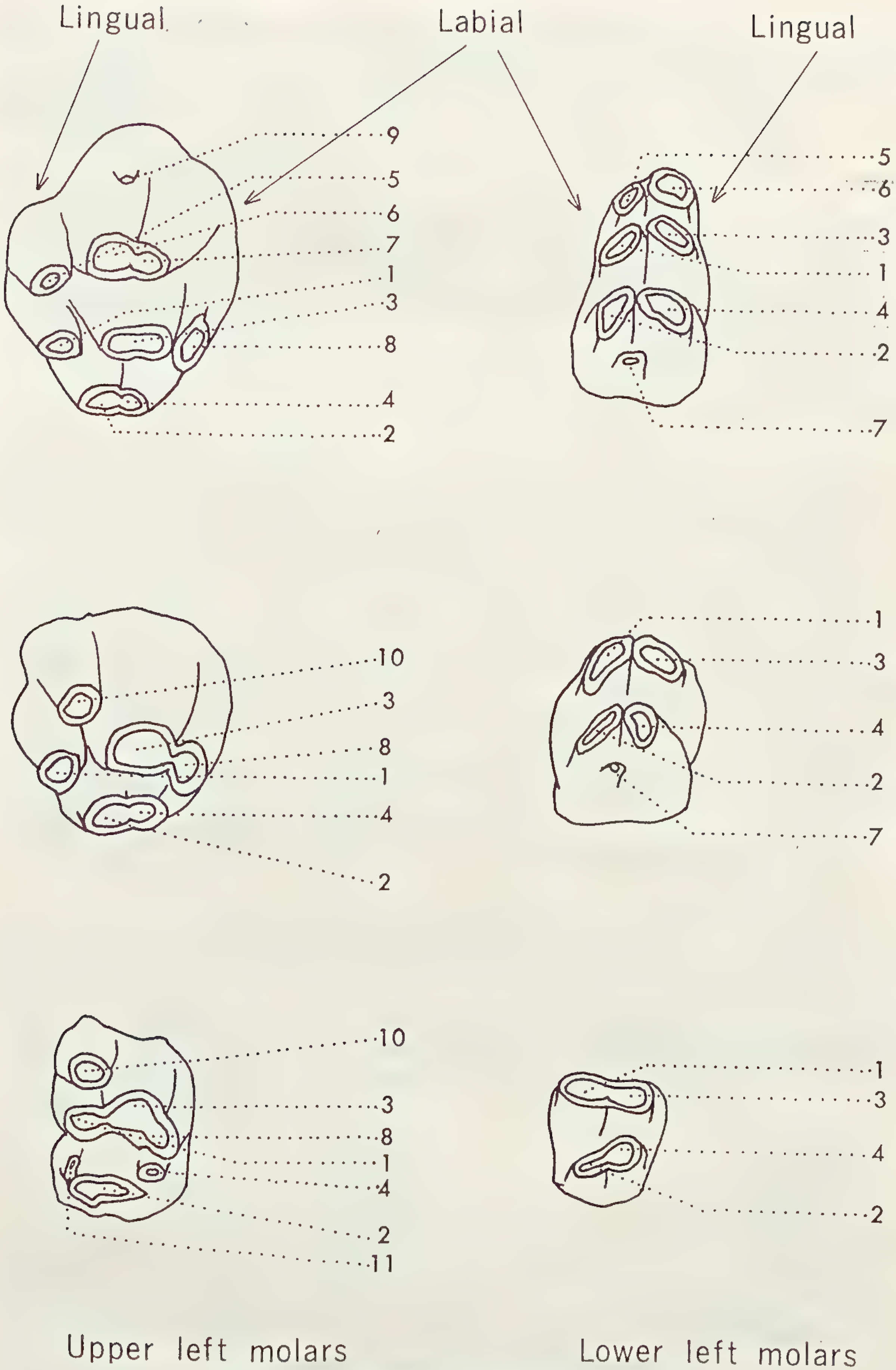


Figure 4 (for explanation see bottom of next page)

TABLE 2. Measurements of skull and upper molars of *Mastacomys wombeyensis* specimens, in mm.

Specimen			AMEU No. B59/a	PM 6170‡	F 52303		PM 5861		PM 7333	F 52304	PM 7556
Character			Left	Left	Left	Right	Left	Right	Right	Left	Left
Length of cheek tooth row (occlusual aspect)			9.0	..	8.2	8.4	*e*9.9	†	..	..	..
Length of wear surface for cheek tooth row			7.8	..	6.8	7.1	*e*8.4	†	..	..	..
Alveolar length, cheek tooth row..			8.9	7.1	†	8.3	9.3	*e*9.3	..	..	..
M^1 ..	Length ..	Tooth base ..	..	..	3.05	3.05	3.34	*e*3.4	*e*3.1	†	†
		Occl. surf ..	..	..	2.5	2.6	3.1	†	*e*3.0	†	†
	Width	.. .. ..	..	..	2.82	2.80	3.20	*e*3.2	†	†	†
M^2 ..	Length ..	Tooth base ..	..	..	2.26	2.25	2.50	†	..	..	..
		Occl. surf ..	..	..	2.1	2.3	*e*2.4	†	..	..	..
	Width*	.. .. ..	3.0* ..	.. ..	2.90* 2.84	2.9* 2.82	*e*3.20* 3.10	† †	.. ..	.. ..	.. ..
M^3 ..	Length ..	Tooth base ..	..	..	2.60	2.65	*e*2.4	†	..	..	..
		Occl. surf ..	..	..	2.0	2.1	*e*2.3	†	..	..	..
	Width	.. .. ..	..	..	2.15	2.05	†	..	..	..	..
Least zygomatic plate length (Ride's least width)			5.0	4.1	4.1	4.2	..	..	..	..	..
Length pterygoid fossa			..	..	7.5		..	..	..	..	..
Length diastema			..	..	8.7		..	..	..	..	..
Width of rostrum			..	..	5.0		..	..	..	..	..
Least interorbital width			..	..	3.4		..	..	..	..	..
Midfrontal width			..	..	4.0		..	..	..	..	..
Palatal bridge width			..	..	6.2		..	..	..	..	..
Palatal length			..	..	16.2		..	..	..	..	..

* From anterolingual style to mesostyle.

e — estimate.

† — element present, but not measurable.

‡ An edentulous jaw questionably referred to *M. wombeyensis*. Its zygomatic plate lacks a pronounced anterior prong. This and the similarly noted specimen in table 3 do not figure in the dental (tooth row) specimen counts.

EXPLANATION OF FIGURE 4 (PREVIOUS PAGE)

Generalized composite cusp and style patterns of Broom Cave murids

Upper left molars

1. Protocone.
2. Hypocone.
3. Paracone.
4. Metacone.
5. Anterolingual conule.
6. Anterolabial conule.
7. Anterolabial style.
8. Mesostyle.
9. Anteromedian style.
10. Anterolingual style.
11. Mesostyle.
12. Enterostyle.

Lower left molars

1. Protoconid.
2. Hypoconid.
3. Metaconid.
4. Entoconid.
5. Anterolabial conulid.
6. Anterolingual conulid.
7. Posterolophid.

Terminology based on Hershkovitz (1962)

On F52303, an almost complete skull, the enterostyle is larger on the right side than on the left (plate 1, e). PM 5861 (plate 1, f) is a palate bearing most of the teeth. These teeth are in a more advanced stage of wear, Ride's "age c", than those in F52303 but the enterostyle on the right M^3 is still distinguishable though somewhat fused into the hypocone at this stage.

TABLE 3. Measurements in mm for lower molars of *M. wombeyensis*. All are maximum dimensions at crown base

Specimen	M_1		M_2		M_3	
	Length	Width	Length	Width	Length	Width
PM 6174 ..	3·58	2·40	..	..	..	..
F 52306	3·50	2·04	..	..	..	..
F 52305	†	†	2·05	1·96	1·75	1·49
F 52308	..	..	2·40	†	..	..
PM 6175 ..	..	..	1·97	1·83	..	..
F 52307	†	2·00	..	..	..	..
PM 6178 ..	3·43	2·04	..	..	..	..
PM 6172* ..	†	†	..	..	..	..

* An edentulous specimen. Neither it nor the similarly marked edentulous maxilla shown in table 2 figure in the dental (tooth row) specimen counts.

† Element present, but not measurable.

Some specimens of lower molars, identifiable mainly on size and general morphology, are placed in this species. They are chipped and fragmented to varying degrees. Though not quite as wide as the uppers, they are certainly more massive in character than any other lower molars found in this sample. However, since the type lacks lower molars we cannot be certain. It may be that some of these are very large specimens of *Pseudomys oralis*, though the general character of the teeth and their average size would seem to exclude this.

Pseudomys oralis and *Gyomus glaucus*

A large number of specimens of these species were obtained, and from them estimates of morphological variation have been made (tables 4 and 5). Our measurements represent maximum dimensions at the crown base. Those of the types of *P. oralis* and *G. glaucus* are from Tate (1951). It should be kept in mind that they probably are not exactly comparable since Tate did not specify how he took his measurements. They probably represent dimensions of the occlusal surface, and are therefore apt to be bigger than ours.

TABLE 4. Statistical data for tooth measures of *Pseudomys oralis* from Broom Cave

	N	$\bar{x}$	s	V	Observed range	Tate 1951 B.M. No. 92.8.7.2
Length M^1 ..	25	2.92 ± .034	.17	5.86	3.16—2.74	3.5
Width M^1 ..	24	2.10 ± .021	.10	5.00	2.26—1.93	2.1
Length M^2 ..	18	2.09 ± .036	.16	7.41	2.32—1.76	1.7
Width M^2 ..	18	1.90 ± .029	.12	6.57	2.08—1.64	2.0
Length M^3 ..	14	1.58 ± .025	.09	5.88	1.70—1.40	1.4
Width M^3 ..	14	1.45 ± .028	.10	7.24	1.64—1.34	1.6
Length M_1 ..	26	2.84 ± .030	.15	5.35	3.22—2.56	..
Width M_1 ..	27	1.81 ± .024	.13	7.40	2.14—1.64	..
Length M_2 ..	24	1.87 ± .029	.14	7.49	2.26—1.64	..
Width M_2 ..	26	1.83 ± .027	.14	7.69	1.08—1.52	..
Length M_3 ..	19	1.59 ± .022	.10	6.11	1.74—1.34	..
Width M_3 ..	19	1.45 ± .034	.15	10.2	1.64—1.10	..

Pseudomys oralis Thomas 1921

The variation in the M^1 is marked. F52264 (plate 2a) displays the maximum development of the cusps. A clearly defined anteromedian style is present in some specimens. Lundelius (1964, p. 70) pointed out that this feature is by no means restricted to *Thetomys* as Tate (1951, p. 240) and others have said. The other elements of the procingulum are well developed including a distinct anterolabial style. The mesostyle is well separated from the paracone but the metacone shows incipient fusion into the hypocone. The general trend towards degeneration of the labial elements is shown in a fine series in these specimens. PM 7634 (plate 2b) has the anterolabial style somewhat fused into the anterolabial conule and the metacone has completely merged into the hypocone F52262 (plate 2c) shows similar loss of elements but has also lost the little accessory anteromedian style. The typical cusp pattern is displayed by PM 5878 (plate 2d) where only the anterolabial and anterolingual conules remain of the procingulum.

In M^2 the variation is not nearly as marked as in M^1. The standard pattern has a first lamina comprised of only an anterolingual style, a second lamina of protocone, paracone, and mesostyle, and a third lamina of only the hypocone. Slight variations of the hypocone occur. There may be a grooving on the usually smooth anterior face which is all that remains of a formerly double cusped row, i.e., an advance state of fusion of the metacone with the hypocone (PM 7328, pl. 2e). The hypocone may also bear a slight lingual bulge (F 52270, pl. 2f), the cusp wearing so as to form a comma-shaped lake, or it may wear as two "wings" directed laterally (PM 5885, pl. 2g). All these variations are quite minor and seem to be fairly common throughout the specimens present.

M^3 varies little from the typical pattern expressed for M^2. PM 7636 (pl. 2h) provides an outstanding exception. It bears a clearly defined metacone, completely separated from the hypocone. This is a very rare instance of such a marked development of this primitive condition.

The lower molars show only very little variation. In the $M_{\bar{1}}$ changes in the chevron-like angulation of the second and third laminae occur. In some the central angle between the cusps (arms of the chevron) is less than 90° (F 52281, pl. 2i) and in others it is greater than 90° (PM 5866, pl. 2j). The posterolophid may be missing occasionally.

On $M_{\bar{2}}$ the posterolophid may be quite distinct and apparently functional enough to show wear (F 52284, pl. 2k). More usually (PM 7319, pl. 2l), it is reduced and fused to the base of the hypoconid.

$M_{\bar{3}}$ reveals a tendency to fuse the protoconid and metaconid into a ridge. The entoconid is accentuated with the hypoconid fused into it (PM 7321, pl. 2m). F 52302 (pl. 2n) illustrates a less common condition in which the cusps in the first row are distinct and the hypoconid, though reduced, is also distinct. Variation in size and proportion of the lower molars of *P. oralis* is shown in the scatter diagram (fig. 5).

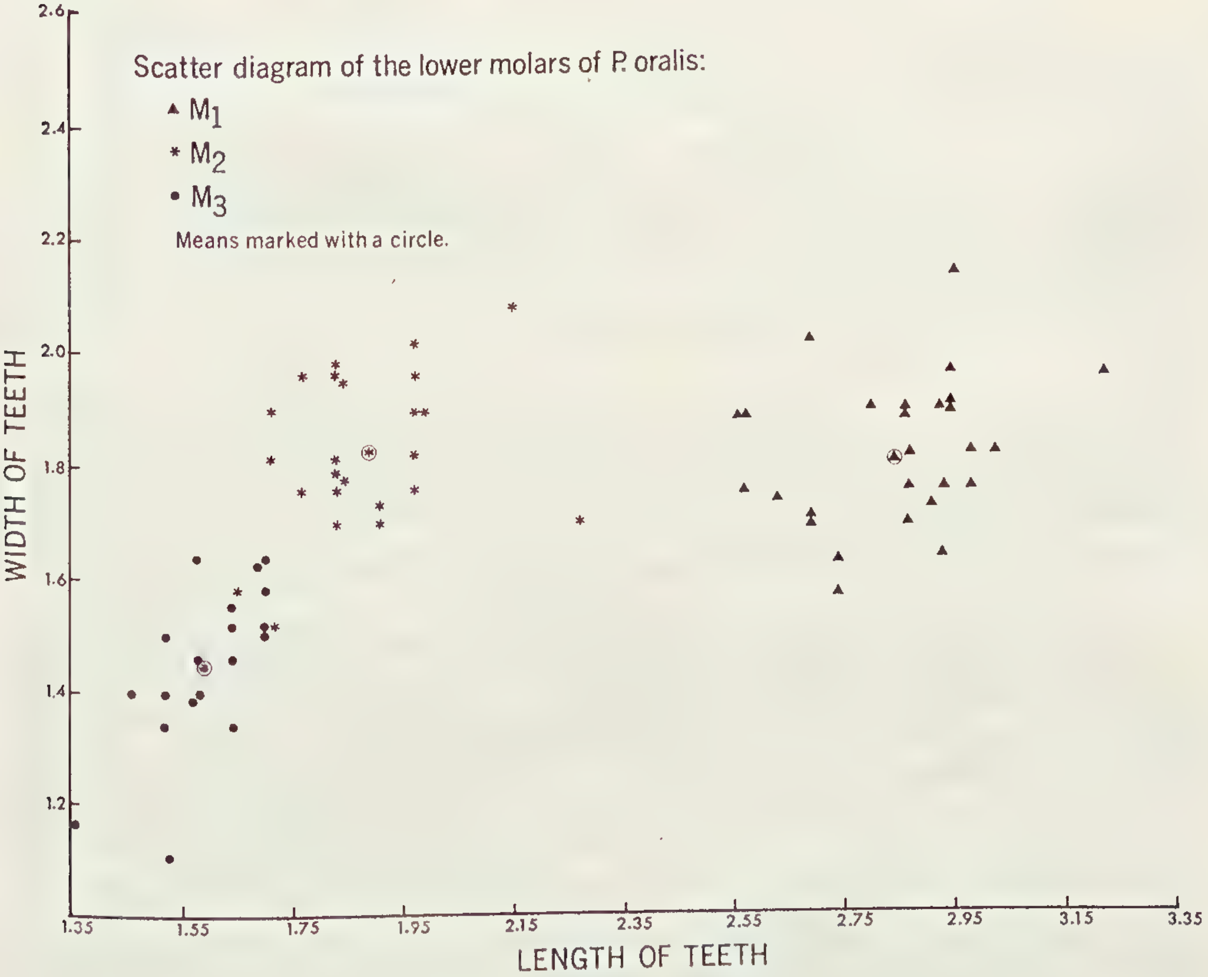


Figure 5

Gyomys glaucus Thomas 1910

This species shows less variation in cusp and style development than does *P. oralis*. $M^{\underline{1}}$ usually does not carry an anterolabial style. A few specimens have it (PM 7605, PM 5922, pl. 3b and a), but in these it is degenerate and partly fused into the anterolabial conule. Few cases of the accessory anteromedian style have been seen, PM 6179 (pl. 3c) in which it is marked, and F 52192 (pl. 3d) in which it is reduced. It may be significant that the variants of anteromedian style and anterolabial style have not been observed together on a specimen. M^2 is also less varied than that of *P. oralis* except for one specimen (F 52185, pl. 3g), which has the second lamina bent back at an angle towards the hypocone instead of running in a gentle arc across the whole width of the tooth. M^3 presents only minor variations in cusp union with the onset of age.

The lower molars of *G. glaucus* are even more uniform in style and cusp development than the uppers and show none of the minor variations (fusions) that are evident in *P. oralis*.

TABLE 5. Statistical data for tooth measures of *Gyomys glaucus* from Broom Cave

	N	$\bar{x}$	s	V	Observed	Tate 1951 BM No. 92.8.7.2
Length M^1	35	2.15 ± .017	.10	4.79	2.32—1.90	2.0
Width M^1	37	1.52 ± .019	.12	8.15	1.78—1.23	1.4
Length M^2	31	1.52 ± .030	.17	11.0	1.89—1.23	1.2
Width M^2	33	1.35 ± .025	.14	10.7	1.66—1.10	1.3
Length M^3	22	1.10 ± .024	.11	10.1	1.29—0.92	0.9
Width M^3	22	1.00 ± .026	.12	12.3	1.16—0.80	1.0
Length M_1	33	2.07 ± .023	.13	6.37	2.32—1.84	..
Width M_1	33	1.19 ± .019	.11	9.49	1.44—1.01	..
Length M_2	35	1.40 ± .017	.10	7.35	1.59—1.16	..
Width M_2	35	1.29 ± .036	.22	16.7	1.58—1.04	..
Length M_3	32	1.14 ± .016	.10	8.77	1.34—0.86	..
Width M_3	32	1.01 ± .015	.09	9.10	1.16—0.74	..

In contrast to the slight degree of variation in cusp and style development in *G. glaucus*, some of the coefficients of variation (V's) of certain tooth measures for this species offer a different picture (tables 4 and 5). The value of V is consistently high for upper M^2 and M^3, whereas most values for the other teeth are more in line with what might be expected. Such high values usually indicate a mixed sample. Conceivably there may be other taxa included in the series, but because of the overall morphological consistency of form and lack of variation of detail in cusp and style development, we think this is not the case. Nor do all of the V's suggest a mixed sample. It is most unlikely that age variations in the measured teeth could account for the high V's, for all the measurements were taken at the crown bases in order to eliminate wear as a factor. This was done in order to utilize all specimens. Hence the measurements at all age classes are essentially comparable to maximum length and width of teeth at Ride's class "e" age. We can offer no conclusive explanation for the high V's, but a possible one is that teeth are inherently more variable than the others. This may be true for the entire population, or perhaps this is a secondary sexual variation, which might be ascertained if the specimens could be sexed.

The striking differences in variability in *G. glaucus* between the relatively stable cusp and loph form and arrangement on one hand, and the highly varied dimensions of some teeth on the other, may be related to small size for it is quite likely that selective advantages in grinding efficiency can accrue in a variety of ways. Probably two such ways are by (1) a relative increase in tooth size without an accompanying structural change, and (2) by a relative increase in occlusual surface complexity without any significant size change. If this is the case, the smaller *G. glaucus* may be thought of as following the second alternative, and the larger *P. oralis* the first one. If size is indeed the critical factor, a check should be possible for parallels to this situation should then be found elsewhere within other groups of small rodents.

TABLE 6. Measurements of the teeth of the *Rattus* sp. specimens in the Broom Cave fauna. Dimensions are given in mm, and represent maximum measures taken at the base of the crown

Specimens	M^1		M^2		M_2	
	Length	Width	Length	Width	Length	Width
PM 7337 ..	..	..	2.14	1.96	..	..
F 52310	..	..	2.08	2.14	..	..
PM 16184 ..	3.62	2.51	..	..	..	..
F 52309	3.25	2.08	1.96	2.02	..	..
PM 16183 ..	..	..	..	..	2.08	1.96

Rattus sp.

The genus *Rattus* is reported to have a typical root pattern by Wood Jones (1922) and Ride (1960). On the basis of the general *Rattus*-like crown morphology and this peculiar (typical) root pattern we have assigned five of our specimens to the genus (pl. 1a, b, c, d). No species determination has been attempted for them. The Murines are extremely difficult to classify on the basis of dental characters and we lack the comparative materials that would permit one to distinguish between isolated teeth of animals of Ride's (1960, p. 75) Groups I, II or the *Uromys*-branch of his Group III. Ride delineates these as follows: "Australian Murinae may be divided into three groups (see Tate 1951) which are: Group I, "Modern introductions", e.g., *Rattus rattus*, *R. norvegicus*, *Mus musculus*; Group II, "Young endemics", e.g., species of *Rattus* which have probably evolved in Australia, including the *R. assimilis* and *R. lutreolus* species groups; Group III, "old endemics", i.e., Murinae of genera peculiar to Australia and the adjacent islands".

From what can be seen on the Broom Cave specimens, we at first felt certain of an assignment to the genus *Rattus* (pl. 1a, b), but examination of root patterns of a few recent specimens of the *Uromys*-branch (*Melomys platyops fuscus* 54181) makes this now seem less certain (pl. 1i). Further investigation of the root pattern and its variation for a variety of Australian species of *Rattus*, *Uromys* and especially *Melomys*, which though similar to *Rattus* seems to have more roots than *Rattus*, is in order if a firm assignment of such isolated teeth is to result. It nevertheless is clear that the fauna does contain either a *Rattus* or a near relative of *Rattus*.

Ride (1960) commented on the absence from the fauna as known to him of a representative of any "modern introduced" *Rattus* or *Mus*, "young endemic" *Rattus*, or of a *Uromys*-branch "old endemic". Tate (1951, p. 318-320) has recognized four, possibly five, major divisions of the genus *Rattus* for the Australia-New Guinea region.

Two of these presumably would have been in Australia at the time of the operative Broom Cave: the members of the *Rattus assimilis* division (*R. assimilis*, *R. ruber*, *R. leucops*, and *R. niobe* groups) generally rainforest inhabitants, and those of the *Rattus lutreolus* division (*R. lutreolus*, *R. youngi*, *R. sordidus*, and *R. gestri* groups) typically are found in an open forest environment.

The presence of a *Rattus* in the fauna now raises some new alternatives with regard to the former observations about this assemblage. (1) The fauna may be younger than has been thought. The *Rattus* (sensu stricto) invasion of the Australian mainland is usually thought to have been a relatively recent occurrence in relation to the overall history of the murids on the continent. (2) *Rattus* actually may have arrived in Australia somewhat earlier than had been thought. The Broom Cave *Rattus* would then be the expression of this very early invasion. At present there seems to be no basis for making a choice between these alternatives.

SUMMARY

The largest sample yet reported of the murid element of the Broom Cave fauna, Late Pleistocene, New South Wales, Australia, has been examined. Included is a small series of specimens of *Mastacomys wombeyensis* Ride, a species previously known only from its type. Variations in dental morphology are described and statistical data are set down for series of *Pseudomys oralis* and *Gyomus glaucus*. In addition to these three species which had been previously reported, a new record, *Rattus* sp., is registered. Some observations on age distributions and an age-spread determination of the absolute minimum numbers of individuals represented are made. A method is advanced for making a conservative estimate of the maximum number of individuals represented, which in the case of undisturbed owl pellet deposits closely approximate the actual number of individuals in the sample.

ACKNOWLEDGMENTS

The authors wish to thank the following for critical reading of the manuscript and for offering suggestions or discussion: E. L. Lundelius, Jr, R. G. Johnson, E. C. Olson, P. F. Turnbull, R. Zangerl, J. Clark, and H. J. Fletcher.

BIBLIOGRAPHY

Broom, R., 1895a. On a Small Fossil Marsupial with Large Grooved Premolars. *Proc. Linn. Soc N.S.W.* 20: 563–567, pls XLV and XXV.

———1895b. On a Small Fossil Marsupial Allied to *Petaurus*. *Proc. Linn. Soc. of N.S.W.* 20: 568–570, pl. XLVI.

———1896. Report on a Bone Breccia Deposit Near Wombeyan Caves, N.S.W.; with description of Some New Species of Marsupials. *Proc. Linn. Soc. N.S.W.* 21: 48–61, pls VI–VIII.

Ellerman, J. R., 1941. The Families and Genera of Living Rodents. British Museum of Natural History, London, 2: 1–690, figs, 1–50.

Hershkovitz, P. 1962. Evolution of Neotropical Cricetine Rodents (Muridae), With Special Reference to the Phyllotine Groups. *Fieldiana, Zool.*, 46: 1–524, figs 1—123.

Lundelius, E. L. Jr., 1964. Notes on the Skulls of Two Western Australian Rodents With a Key to the Skulls of Rodents of Southwestern Australia. *J.R. Soc. West. Aust.*, 47: Pt 3, 65–71, figs 1–7.

Ride, W. D. L., 1956a. The Affinities of *Burramys parvus* Broom, A Fossil Phalangeroid Marsupial. *Proc. Zool. Soc. London*, 127: 413–429, figs 1–3, pls 1–2.

———1956b. A New Fossil Mastacomys (Muridae) and a Revision of the Genus. *Proc. Zool. Soc. London*, 127: 431–439, figs 1–2.

———1960. The Fossil Mammalian Fauna of the *Burramys parvus* Breccia From the Wombeyan Caves, New South Wales. *J.R. Soc. West. Aust.*, 43: Pt 3, 74–80, 1 fig.

Tate, G. H. H., 1951. The Rodents of Australia and New Guinea. *Bull. Amer. Mus. Nat. Hist.* 97: Art. 4, 183–430, figs 1–4, tables 1–5.

Wood Jones, F., 1922. On the Dental Characters of Certain Australian Rats. *Proc. Zool. Soc. London* 41: 587–598, figs 1–12.

APPENDIX

LIST OF MATERIALS STUDIED

Gyomys glaucus

- L. Maxillae, wear stage—
  - B: PM 5922 with M^{1-2}.
  - C: F 52171 with M^{1-2}; F 52172 with M^{1-3}.
  - E: PM 5921 with M^{1-2}.
- L M^1, wear stage—
  - B: F 52173, F 52174, PM 16141.
  - C: F 52175, F 52176, F 52177, PM 16140, PM 16146, PM 16147.
  - D: F 52178, F 52179, PM 7660.
- L. M^2, wear stage—
  - B: F 52180, F 52181, PM 16144.
  - C: F 52182, F 52183, F 52184, F 52185, PM 7562, PM 7564, PM 16142.
  - D: F 52186, F 52187, PM 7654, PM 16143.
- L. M^3, wear stage—
  - B: F 52188.
  - C: F 52189, PM 7658.
  - D: F 52190, PM 7381, PM 7646.
  - E: F 52191.
- R. Maxillae, wear stage—
  - C: F 52192, PM 5914 with M^{1-3}; PM 16138 with M^{1-2}.
  - D: F 52193, PM 5913 with M^{1-3}; PM 5912 with M.$^{2-3}$
- R. M^1, wear stage—
  - A: PM 5917, PM 7676.
  - B: F 52194, F 52195, F 52196, PM 6179, PM 7383, PM 7653.
  - C: F 52197, F 52198, F 52199, F 52200, PM 5915, PM 5916, PM 7605, PM 7652.
  - D: F 52201.
- R. M^2, wear stage—
  - B: F 52202, PM 7656.
  - C: F 52203, F 52204, F 52205, F 52206, PM 7679, PM 7680, PM 7977, PM 7978.
  - E: PM 7384.
- R. M^3, wear stage—
  - C: F 52207, F 52208, F 52209, PM 7387, PM 7567, PM 7980, PM 16137.
  - D: F 52210, F 52211, F 52212, PM 7663, PM 7979.
  - E: F 52213, F 52214, PM 7388.
- L. Mandibles, wear stage—
  - B: F 52215 with M_{1-3}
  - C: F 52216 with M_{2-3} and PM 5901, PM 7343 with M.$_{1-3}$
  - D: F 52217 and F 52218 with M_{1-2}; PM 7638 and PM 16159 with M_{1-3}.
  - E: F 52219 with M_{1-3}.
  - Edentulous PM 5890.
- L. M_1, wear stage—
  - B: PM 7641.
  - C: F 52220, F 52221, F 52222, PM 7572, PM 7610, PM 7611, PM 16155.
  - D: F 52223, F 52224, PM 7642.
- L. M_2, wear stage—
  - B: F 52225, F 52226, F52227. PM 7612, PM 7645, PM 16156, PM 16157.
  - C: F 52228, F 52229, F 52230, PM 7643, PM 7644, PM 16160.
  - D: F 52231.
- L. M_3, wear stage—
  - A: PM 7575.
  - B: F 52232, PM 7358.
  - C: F 52233, F 52234, PM 7574, PM 7613.
  - D: F 52235, PM 7573.
  - E: PM 7356.
- R. Mandibles, wear stage—
  - C: F 52236 and PM 16154 with M_{1-2}; F 52237, PM 7346 with M_{1-3}; PM 7568 with M_{2-3}.
  - D: F 52238 with M_{1-3}; PM 5892 with M_{1-2}.
  - Edentulous: F 52239, PM 7345, PM 7639.

R. $M_{\overline{1}}$, wear stage—
A: F 52240.
B: F 52241, PM 7361, PM 7609.
C: F 52242, F 52243, F 52244, PM 16148, PM 16149.
D: PM 7608.
E: F 52245.

R. $M_{\overline{2}}$, wear stage—
A: F 52246.
B: F 52247, PM 7365, PM 7570.
C: F 52248, F 52249, PM 16150.
D: PM 7364.

R. $M_{\overline{3}}$, wear stage—
A: F 52250.
B: F 52251, F 52252, PM 7640, PM 16151.
C: F 52253, PM 16152.
D: F 52254, PM 16153.
E: PM 7373.

Pseudomys oralis

L. maxillae, wear stage—
C: F 52255 with $M^{\underline{1-2}}$, PM 5878 with $M^{\underline{1-3}}$.
D: F 52256 with $M^{\underline{1-3}}$; PM 16173 with $M^{\underline{1-2}}$.

L. $M^{\underline{1}}$, wear stage—
B: PM 16169.
C: F 52257, F 52258, PM 16168.

L. $M^{\underline{2}}$, wear stage—
B: PM 7328.
C: F 52259.
D: PM 16171.

L. $M^{\underline{3}}$, wear stage—
B: F 52260.
D: F 52261, PM 7637.

R. maxillae, wear stage—
C: PM 7603, PM 7636, PM 16167 with $M^{\underline{1-3}}$.
D: PM 7559 with $M^{\underline{1-2}}$.

R. $M^{\underline{1}}$, wear stage—
B: F 52262, PM 7634.
C: F 52263, F 52264, F 52265, F 52266, F 52267, PM 7331, PM 7332, PM 7334, PM 7335, PM 16163.
D: F 52268.
E: PM 16164.

R. $M^{\underline{2}}$, wear stage—
B: F 52269, PM 7386.
C: F 52270, F 52271, PM 5885, PM 16165.
E: PM 7338.

R. $M^{\underline{3}}$, wear stage—
B: F 52272.
C: F 52273, F 52274, PM 7662.
D: PM 7635.
E: F 52275.

L. mandibles, wear stages—
B: F 52276, with $M_{\overline{1-2}}$.
C: F 52277, F 52278, PM 7307 with $M_{\overline{2-3}}$, PM 5865, PM 6171 with $M_{\overline{1-3}}$.
E: F 52279 with $M_{\overline{1-3}}$.
Edentulous: PM 7303.

L. $M_{\overline{1}}$, wear stage—
B: F 52280, PM 5812.
C: F 52281, F 52282, PM 5873, PM 7305, PM 7308.
E: F 52283, PM 16178.

L. $M_{\overline{2}}$, wear stage—
A: F 52284.
B: F 52285, F 52286, PM 7318, PM 16180.
C: F 52287, F 52288, PM 7633, PM 16179.
L. $M_{\overline{3}}$, wear stage—
A: PM 7321.
B: F 52289, F 52290, PM 16181.
C: F 52291, PM 7647.
D: PM 5869.
R. mandibles, wear stage—
C: F 52292 with $M_{\overline{1-3}}$; PM 5866 with $M_{\overline{1-2}}$.
D: F 52293 with $M_{\overline{1-2}}$; PM 6180 with $M_{\overline{1-3}}$.
E: F 52294 with $M_{\overline{1-3}}$; PM 16176 with $M_{\overline{2-3}}$.
Edentulous: F 52295, PM 7302.
R. $M_{\overline{1}}$, wear stage—
B: PM 5868.
C: F 52296, F 52297, F 52298, PM 7317, PM 7558, PM 7631.
D: F 52299.
R. $M_{\overline{2}}$, wear stage—
B: F 52300, F 52301, PM 7319.
C: PM 5863.
R. $M_{\overline{3}}$, wear stage—
B: F 52302, PM 7320.

Mastacomys wombeyensis—
Palates and maxillaries, wear stage—
B: F 52303 with L. $M^{\underline{1-3}}$ and R. $M^{\underline{1-3}}$.
C: PM 5861 with L. $M^{\underline{1-3}}$ and R. $M^{\underline{1-2}}$.
Edentulous: PM 6170, a R. maxillary questionably referred.
L. $M^{\underline{1}}$, wear stage—
B: PM 7556.
C: F 52304.
R. $M^{\underline{1}}$, wear stage—
C: PM 7333.
L. mandibles, wear stage—
C: F 52305 with $M_{\overline{1-3}}$.
Edentulous: PM 6172.
L. $M_{\overline{1}}$, wear stage—
C: PM 6178.
R. mandibles, wear stage—
C: F 52306 and PM 6174 both with $M_{\overline{1}}$.
R. $M_{\overline{1}}$, wear stage—
B: F 52307.
R. $M_{\overline{2}}$, wear stage—
C: PM 6175.
D: F 52308.

Rattus sp.
L. maxillary, wear stage—
C: F 52309 with $M^{\underline{1-2}}$.
L. $M^{\underline{2}}$, wear stage—
C: F 52310.
R. $M^{\underline{1}}$, wear stage—
C: PM 16184.
R. $M^{\underline{2}}$, wear stage—
B: PM 7337.
R. $M_{\overline{2}}$, wear stage—
D: PM 16183.

Table 1. Age group assignments of teeth of *Gyomys glaucus* from the Broom Cave fauna using Ride's age designation (Ride, 1956a, p. 433). Age group classes are as follows: (a) distinct cusps on all molars, (b) wear beginning to unite cusps into laminae, (c) all cusps united transversley but cusps still discernible, (d) cusps no longer discernible, (e) laminae themselves disappearing. First column under each age group gives numbers of individual teeth. Second columns give the maximum numbers of specimens of that molar quadrant that are represented by the individual teeth of the first columns after all known correlations have been accounted for.

	A		B		C		D		E		Totals	
	teeth	spec.	teeth	spec.	teeth	spec.	teeth	spec.	teeth	spec.	teeth	spec.
L. M^1 .. L. M^2 .. L. M^3 ..	0 0 0	0	4 4 1	8	8 9 3	17	3 4 3	*10*	1 1 2	2	16 18 9 43	37
R. M^1 .. R. M^2 .. R. M^3 ..	**2** 0 0	2	6 2 0	8	**11** **11** 9	***25***	4 3 **8**	9	0 1 **3**	*4*	23* 17 20 60	48
L. M$_1$ .. L. M$_2$ .. L. M$_3$ ..	0 0 1	1	2 **8** 3	***11***	9 9 7	21	7 5 4	*10*	1 1 2	2	19 23 17 59	45
R. M$_1$ .. R. M$_2$ .. R. M$_3$ ..	1 1 1	*3*	3 3 4	10	9 8 6	15	3 3 3	6	1 0 1	2	17 15 15 59	36
Total number of teeth ..	6	..	40	..	99	..	50	..	14	..	209	..
Total number of specimens ..	..	6	..	37	..	78	..	35	..	10	..	166†
Most frequently represented tooth	**2**	..	**8**	..	**11**	..	**8**	..	**3**	..	32‡	..
No. of specimens in largest suite	..	*3*	..	*11*	..	*25*	..	*10*	..	*4*	..	53¶

* Traditional assessment of minimum number of individuals.

† Absolute maximum number of specimens and individuals (based on all teeth, correlated and uncorrelated).

‡ Age-spread assessment of minimum number of individuals.

¶ Minimal estimate of max. number of individuals.

TABLE 2. Age group assignments for teeth of *Pseudomys oralis* from the Broom Cave fauna. Letters and symbols as in appendix table 1

	A		B		C		D		E		Totals	
	teeth	spec.	teeth	spec.	teeth	spec.	teeth	spec.	teeth	spec.	teeth	spec.
L. M^1	0	0	1	3	5	6	2	*5*	0	0	8	14
L. M^2	0		1		3		**3**		0		7	
L. M^3	0		1		1		**3**		0		5	
											20	
R. M^1	0	0	2	5	**13**	*20*	2	3	1	*3*	18*	31
R. M^2	0		2		7		1		1		11	
R. M^3	0		1		6		1		1		9	
											38	
L. M_1	0	*2*	3	*10*	8	16	2	3	1	1	14	32
L. M_2	**1**		**5**		9		0		1		16	
L. M_3	**1**		3		7		1		1		13	
											43	
R. M_1	0	0	1	6	8	9	**3**	3	1	*2*	13	20
R. M_2	0		3		3		2		**2**		10	
R. M_3	0		2		1		1		**2**		6	
											29	
Total number of teeth	2	..	25	..	71	..	21	..	11	..	130	..
Total number of specimens ..	..	2	..	24	..	51	..	14	..	6	..	97†
Most frequently represented tooth	**1**	..	**5**	..	**13**	..	**3**	..	**2**	..	24‡	..
No. of specimens in largest suite	..	*2*	..	*10*	..	*20*	..	*5*	..	*3*	..	40¶

Table 3. Age group assignments for teeth of *Mastacomys wombeyensis* from the Broom Cave fauna. Letters and symbols as in appendix table 1

	A		B		C		D		E		Totals	
	teeth	spec.	teeth	spec.	teeth	spec.	teeth	spec.	teeth	spec.	teeth	spec.
L. M^1	0	0	2	2	2	2	0	0	0	0	4*	4
L. M^2	0		1		1		0		0		2	
L. M^3	0		1		1		0		0		2	
				2		3					8	5
R. M^1	0	0	1	1	2	2	0	0	0	0	3	3
R. M^2	0		1		1		0		0		2	
R. M^3	0		1		0		0		0		1	
											6	
L. M_1	0	0	0	0	2	2	0	0	0	0	2	2
L. M_2	0		0		1		0		0		2	
L. M_3	0		0		1		0		0		1	
				1		5		1			5	7
R. M_1	0	0	1	1	2	3	0	1	0	0	3	5
R. M_2	0		0		1		1		0		2	
R. M_3	0		0		0		0		0		0	
											5	
Total number of teeth ..	0	..	8	..	14	..	1	..	0	..	23	..
Total number of specimens ..	..	0	..	3	..	8	..	1	..	0	..	12†
Most frequently represented tooth	0	..	2	..	2	..	1	..	0	..	5‡	..
No. of specimens in largest suite	..	0	..	2	..	3	..	1	..	0	..	6¶

TABLE 4. Age group assignments for teeth of *Rattus* sp. from the Broom Cave fauna. Letters and symbols as in appendix table 1

	A		B		C		D		E		Totals	
	teeth	spec.	teeth	spec.	teeth	spec.	teeth	spec.	teeth	spec.	teeth	spec.
L. M^1	0	0	0	0	1	*2*	0	0	0	0	1	2
L. M^2	0		0		**2**		0		0		2*	
L. M^3	0		0		0		0		0		0	
											3	
R. M^1	0	0	0	*1*	1	1	0	0	0	0	1	2
R. M^2	0		**1**		0		0		0		1	
R. M^3	0		0		0		0		0		0	
											2	
L. M_1	0	0	0	0	0	0	0	0	0	0	0	0
L. M_2	0		0		0		0		0		0	
L. M_3	0		0		0		0		0		0	
											0	
R. M_1	0	0	0	0	0	0	0	*1*	0	0	0	1
R. M_2	0		0		0		**1**		0		1	
R. M_3	0		0		0		0		0		0	
											1	
Total number of teeth ..	0	..	1	..	4	..	1	..	0	..	6	..
Total number of specimens ..	..	0	..	1	..	3	..	1	..	0	..	5†
Most frequently represented tooth	0	..	**1**	..	**2**	..	**1**	..	0	..	4‡	..
No. of specimens in largest suite	..	0	..	*1*	..	*2*	..	*1*	..	0	..	4¶

EXPLANATION OF PLATES

Plate 1

(Scales indicate length of 2 mm)

Rattus sp.: (a and b), labial and occlusal views of F 52309 L. max. displaying typical *Rattus* root patterns and cusp and style arrangement; (c and d), PM 16183 R. $M_{\overline{2}}$ of wear stage "d" (see text or appendix) showing typical lower root pattern for *Rattus*.

Mastacomys wombeyensis: (e), palatal view of skull, F 52303 showing the diagnostic enterostyles on $M^{\underline{3}}$ indicated with arrows; (f), PM 5861, a palate displaying an enterostyle partially fused into the hypocone; (g), PM 6174, a R. ramus with $M_{\overline{1}}$; (h) F 52308 a R.$M_{\overline{2}}$ of wear stage "c".

Melomys platyops fuscus: (i) 54181, a recent specimen of the Field Museum, displaying the *Rattus*-like cusp and style pattern and the multiplicity of roots characteristic of *Rattus* and near-*Rattus* forms.

Plate 2

(Scale indicates length of 2 mm)

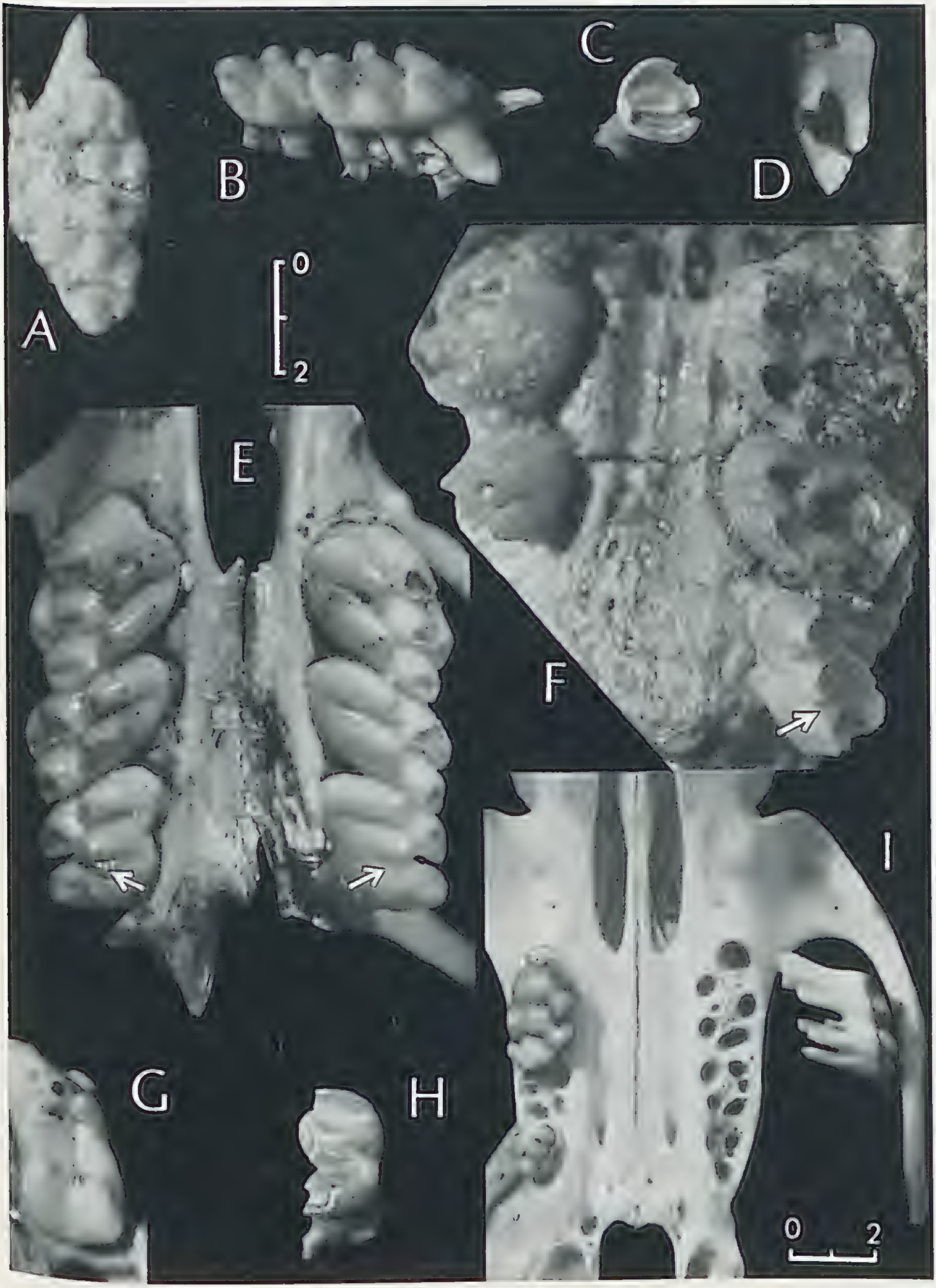
Pseudomys oralis: (a), F 52264 R$M^{\underline{1}}$ displaying maximum development of cusps and styles, a well developed anteromedian style, all conules and style well differentiated on the procingulum, mesostyle well separated and the metacone still distinguishable from the hypocond; (b), PM 7364 R$M^{\underline{1}}$ with the labial elements beginning to atrophy; (c), F 52262 R$M^{\underline{1}}$ showing similar losses as PM 7364 and also lacking an anteromedian style; (d), PM 5878 L. max., an example of the more typical cusp and style pattern of the upper molars; (e), PM 7328 L$M^{\underline{2}}$, with the metacone fusing into the hypocone; (f), F 52270 R$M^{\underline{2}}$, fusion complete, hypocone wearing with a labially directed lake; (g), PM 5885 RM,$^{\underline{2}}$ with the hypocone wearing with two comma-shaped lakes; (h) PM 7636 R. max., with a well developed metacone on the $M_{\overline{3}}$; (i), F 52281 L$M_{\overline{1}}$ having the central angle between the cusps less than 90°; (j), PM 5866, right ramus, the angle between the cusps is greater than 90°; (k), F 52284, L$M_{\overline{2}}$, with the posterolophid as a functional cusp; (l), PM 7319, R$M_{\overline{2}}$, having the posterolophid reduced; (m), PM 7321, L$M_{\overline{3}}$, hypoconid fused into entoconid; (n), F 52302, R$M_{\overline{3}}$, possessing a distinct though reduced hypoconid.

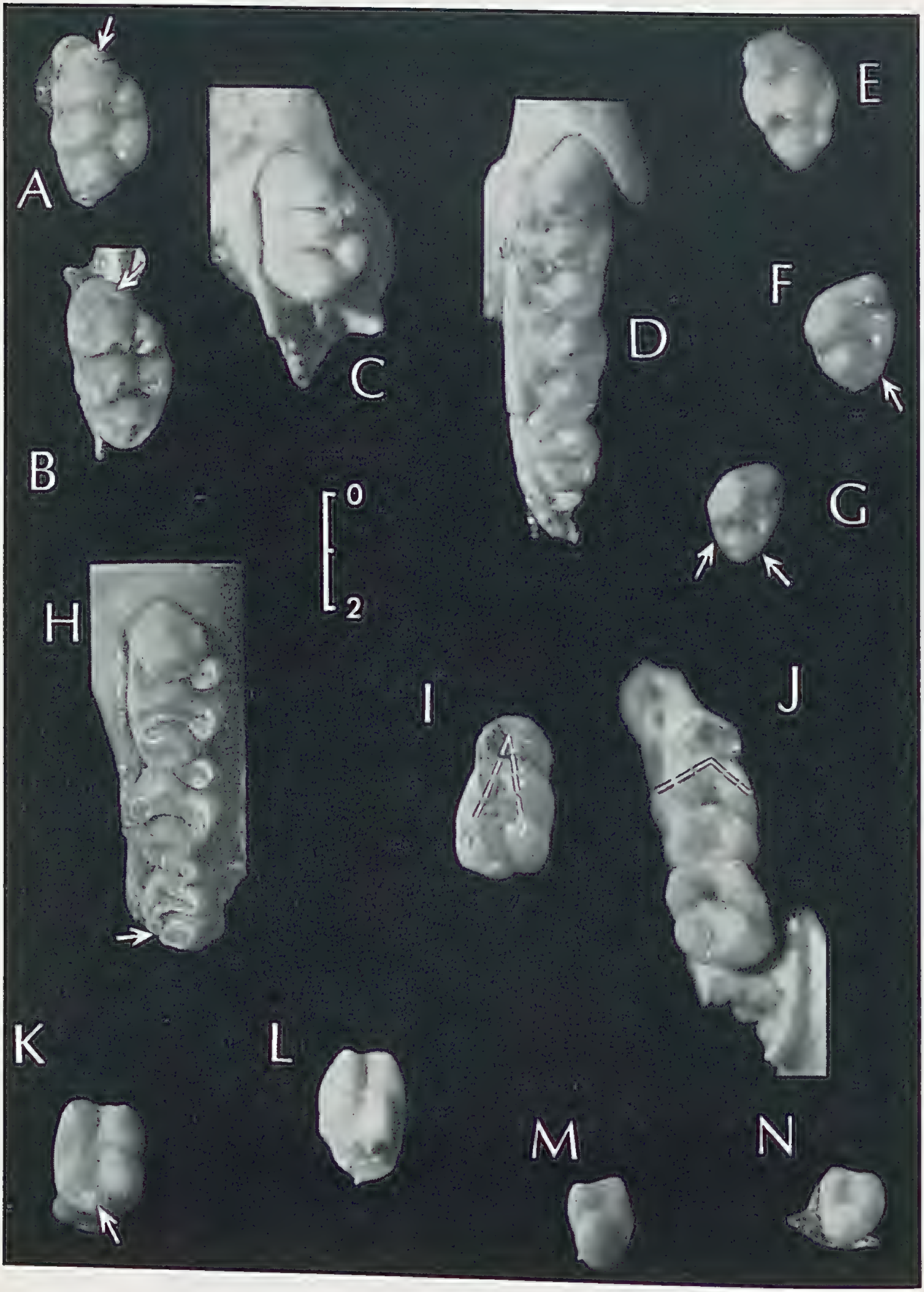
Plate 3

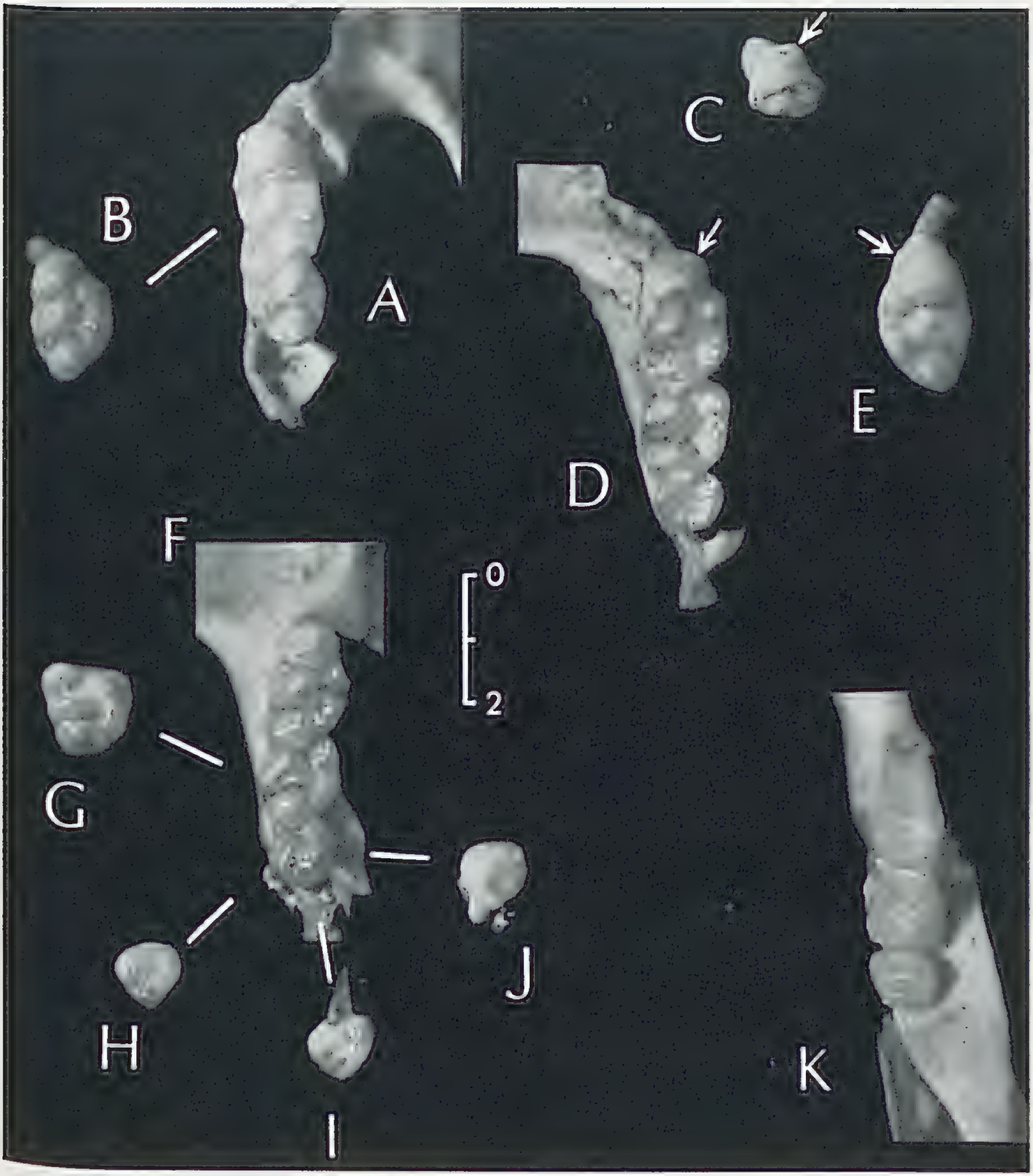
(Scale indicates length of 2 mm)

Gyomys glaucus: (a), PM 5922, L. max., with degenerate anterolabial style fusing into the anterolabial conule; (b), PM 7605 R$M^{\underline{1}}$ showing the same pattern as above; (c), PM 6179, R$M^{\underline{1}}$, having a well developed anteromedian style; (d), F 52192, R. max., see reduced anteromedian style on $M^{\underline{1}}$; (e), F 52177 L$M^{\underline{1}}$ displaying an anteromedian style; (f), PM 5914, R. max., which possesses the typical cusp and style pattern commonly found in the upper molars of this series; (g), F 52185, L$M^{\underline{2}}$, with the second lamina sharply bent back towards the hypocone; (h, i, j), F 52212, F 52209, PM 7387, R$M^{\underline{3}}$'s which show the range of variation found in this tooth; (k), PM 7346, a R. ramus with $M_{\overline{1-3}}$ conforming to the typical pattern for these teeth.

92202 11.69 V. C. N. BLIGHT, GOVERNMENT PRINTER


A
B
C
D
E
F
G
H
I
0
2
0
2


A
B
C
D
E
F
G
0
2
H
I
J
K
L
M
N


A
B
C
D
E
F
G
H
I
J
K
0
2

Results of an Archaeological Survey of the Hunter River Valley, New South Wales, Australia

Part 1: The Bondaian Industry of the Upper Hunter and Goulburn River Valleys

By David R. Moore
Curator of Anthropology, Australian Museum, Sydney

Plates 4–14. Figures 1–28. Manuscript received, 9th May, 1969

CONTENTS

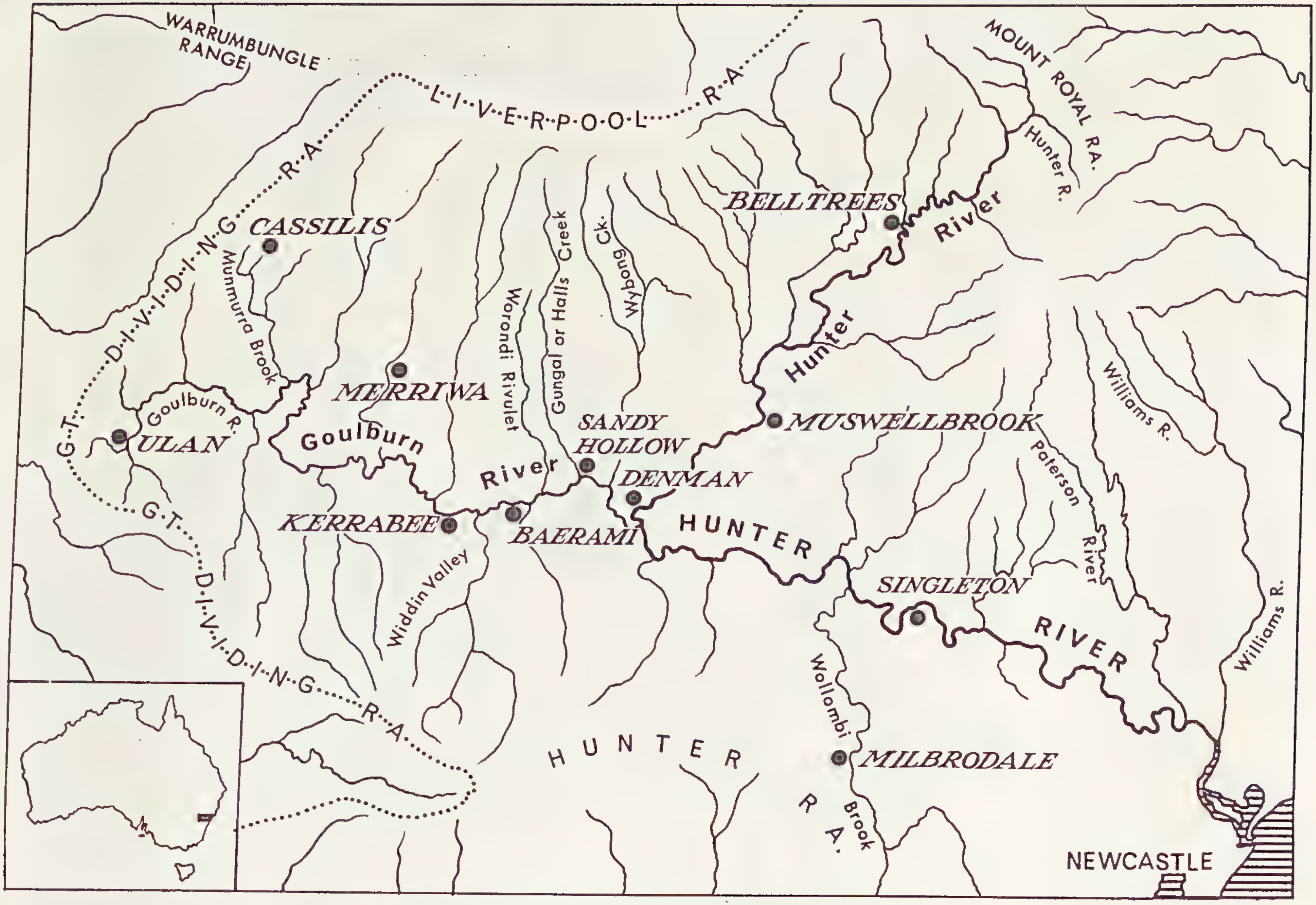
Page
Introduction 27
The Excavations 35
Comparison of Sites 50
Summary and Comment 58
Appendix: Sandy Hollow Burial 61
Acknowledgements 62
References 63

Line Illustrations

Locality Map: Upper Hunter and Goulburn Valleys 26
Figs 1 and 2: Stone Implements 33
Fig. 3: Sandy Hollow (SH/1), ground plan 36
Fig. 4: Sandy Hollow (SH/1), section 36
Fig. 5: Milbrodale (M/1), ground plan 42
Fig. 6: Bobadeen (BOB/1), ground plan 46
Fig. 7: Bobadeen (BOB/1), section 47
Fig. 8: Histograms, comparative occurrence of artefacts 51
Figs 9-28: Frequency Polygons, Bondi Points 54

Plates

Plates 4 and 5: Sandy Hollow Excavation
Plates 6 and 7: Singleton 200-foot Terrace
Plates 8 and 9: Milbrodale Excavation
Plates 10 and 11: Bobadeen Excavation
Plate 12: Backed Blades
Plate 13: Bone Implements
Plate 14: Geometric Microliths



Locality Map: Hunter and Goulburn River systems

INTRODUCTION

Geography

The Hunter River rises in the Mount Royal Range and winds through rolling hilly country in a southwesterly direction as far as Denman, where it is joined by the Goulburn River. Thence it proceeds eastward through an ever-widening valley, mainly in great S-curves, and is joined by several other tributaries, notably Wollombi Brook and the Paterson and Williams Rivers. The Hunter estuary, a complex system of swamp and mangrove, extends from about Raymond Terrace and reaches the ocean in an area of rocky bluffs and sand-dunes at Newcastle.

Since European occupation, the Hunter Valley has suffered periodical floods, but it is likely that flooding was much less severe in the days when only Aborigines inhabited it. Though the flat valley floor and most of the subsidiary valleys have now been cleared by pastoral and agricultural exploitation, at the time of first settlement they were in the main lightly forested (Mitchell, T. L., 1838) and this would have prevented the rapid run-off which now occurs at times of heavy rain.

The Goulburn River, which rises in an undulating section of the Great Dividing Range near Ulan, cuts tortuously through rugged gorges in a generally easterly direction, until it reaches Kerrabee, after which it snakes along a widening valley until it joins the Hunter at Denman. In the course of cutting through the ranges, the Goulburn has carried down a considerable variety of boulders and pebbles, in which cherts and quartzites predominate, and these have been deposited along its lower course and, to a lesser degree, extend into the Hunter itself.

The conglomerate sandstone cliffs which edge the Goulburn and middle Hunter valleys are prone to undercutting and the formation of rock overhangs. The valley fringes are also scattered with huge conglomerate boulders which have fallen from the scarps.

Early observers comment on the well-grassed areas and the park-like appearance of the valley, so in general the Hunter region in its pre-settlement state would have provided excellent hunting grounds with an amplitude of kangaroos, possums, birds, lizards, snakes, and honey, while the rivers themselves would have carried an abundance of fish and shellfish. We can assume also that vegetable foods, nuts, and berries would have been plentiful.

History

The lower Hunter was discovered by Lieutenant J. Shortland in 1797 and was examined by Lt-Colonel William Paterson in 1801, as a result of which a settlement was founded at Newcastle to mine coal and burn shells for lime. Subsequently cedar-cutters gradually penetrated the estuary and lower tributaries as far as where Maitland now stands. The middle and upper Hunter were not settled until after 1819, when an overland route was discovered from Windsor to Singleton by John Howe. The occupation of the Hunter Valley followed rapidly after Benjamin Singleton took up land near the Hunter-Wollombi Brook junction in 1821 and John Howe at Patrick's Plains in 1823.

By 1826 the settlers were petitioning Governor Darling for military protection against the depredations of the Aborigines. When Sir Thomas Mitchell passed through the valley in 1831 on his way to survey the Liverpool Plains, the Hunter was settled as far up as Segenhoe, near Scone.

The history of relations between the early settlers and the Aborigines of the Hunter Valley is poorly documented, but from official records it seems clear that the usual pattern was followed—friendly interest at first, followed by increasing conflict, and ultimately capitulation and disintegration on the part of the Aboriginal local groups. On the other hand, there are also indications that Aborigines were employed on some pastoral properties from the start of settlement, so that relations cannot have been uniformly hostile.

These early accounts have been brought together and analysed by Helen C. Brayshaw, of the University of New England, in an unpublished B.A. thesis (1966) and need not be repeated here. Two points noted in the early accounts are, however, of importance in any consideration of the archaeology of the valley. Firstly, it is stated in a number of places that there was considerable contact, both friendly and hostile, between the Wonarua people of the Middle Hunter and the Gamilaroi of the western slopes of the Dividing Range. There is a specific account of a fight between members of these tribes as far down the valley as the junction of Wollombi Brook and the Hunter (Breton, W. H., 1833). This contact seems to have been made chiefly through what is known as the "Cassilis Gap", an easy way through the otherwise rugged ranges along the line Cassilis-Merriwa-Sandy Hollow. Howitt (1904) states that the Gamilaroi "followed down the heads of the Hunter across from the Talbragar to the Nunmurra waters, and even occasionally made raids as far as Jerry's Plains". He adds that a section of the Gamilaroi "occupied the upper water flowing into the Hunter River, and those which formed the heads of the Goulburn River, for instance the Nunmurra Creek". Since Nunmurra (now Munmurra) Creek flows into the Goulburn between Kerrabee and Wollar, this would seem to imply that the Gamilaroi also came into the Hunter Valley via the gorges of the upper Goulburn. These incursions seem to have been chiefly for trading and to obtain wives, and the latter was probably the cause of the "battles" which are frequently mentioned.

The other information from the historical records which is of immediate interest is that the Wonarua seem to have numbered some 500–600 and occupied the valley from about Sandy Hollow down to about Maitland (Fawcett, J. W., 1898; Miller, R., in Curr, E. M., 1886). The upper Hunter from Muswellbrook northward was the territory of another tribe, the Geawegal. The estuarine part of the lower Hunter appears to have been inhabited by the Gaddhang (or Worimi), who extended north to Port Stephens. There is evidence also for trade between the predominantly coastal Gaddhang and the riverine Wonarua, and of contact between the valley tribes and those to the south, the Awabagal of Lake Macquarie and the Darginung of the Hawkesbury Valley (Dawson, 1830; Howitt, 1904; McCarthy, 1939).

The area we are predominantly concerned with in this report is, then, that of the Wonarua and of their inland contact with the Gamilaroi. However, it would be misleading to give undue prominence to the early reports, since we are dealing with the prehistory of the Hunter Valley and there is not even any guarantee that the people of the upper Hunter during the prehistoric period were ancestral to the historic Wonarua; Aboriginal society was far from static, as we know from important technological changes in the archaeological record elsewhere and from the work of social anthropologists in other parts of the continent.

Previous Research

Although from the very early days settlers have been finding edge-ground axe-heads (called locally "mogos" from a Wonarua term) when ploughing in the Hunter Valley, little interest was taken either in the culture of the surviving Aborigines of the region or in prehistoric remains there. There are, however, a great many relics in the area and no doubt a number have disappeared or been destroyed since settlement. Along the floor of the valley itself the severe flooding, already mentioned, has obliterated practically all traces of prehistoric and post-settlement Aboriginal occupation, but along the scarps and side valleys many interesting relics still survive. These include painted caves, rock engravings, axe-grinding grooves, workshops, and camp sites.

Probably the first person to attempt to record these relics systematically was W. H. Matthews, a surveyor, who in his travels between 1870 and 1910 became deeply absorbed in Aboriginal culture and has left many accounts and scale drawings of Aboriginal relics in various parts of New South Wales and Queensland. While stationed at Singleton Matthews (1893) recorded a number of cave paintings and rock engravings in the Bulga-Milbrodale-Wollombi area, and some of these sites remain intact. Several local residents made extensive collections of Aboriginal artefacts from occupation sites. Notable among these were A. Eather, of Bulga, part of whose collection is in the Australian Museum and part in the Singleton Historical Society's museum, and F. A. Davidson, of Singleton, who collaborated with F. D. McCarthy in investigating the 200-ft terraces bordering the Hunter upstream from Singleton.

McCarthy, while Curator of Anthropology at the Australian Museum, conducted a number of archaeological reconnaissances in areas of importance, and one of these trips, in 1939, was an investigation of the Hunter and Wollombi Valleys. The report of this reconnaissance (in typescript at the Australian Museum) gives a number of useful leads to promising rock shelter deposits and camp sites.

The only other work of direct relevance to the archaeology of the Hunter is the excavations carried out in 1958–1961 by McCarthy and in 1961 by Tindale in the Capertee Valley, some 50 miles southwest from the Hunter as the crow flies. Although there is no easy direct route across the Dividing Range between the Capertee and Hunter valleys, these are the only excavations of stratified sites undertaken scientifically in the locality and are, therefore, useful for comparison when interpreting material from the upper Hunter region.

The Australian Museum Survey, 1965–1967

When the writer commenced work at the Australian Museum in 1965 most of eastern New South Wales was already being covered by other resident archaeologists—Miss (now Dr) Isabel McBryde, of the University of New England, was in the middle of a careful and detailed survey of the Aboriginal relics and occupation deposits of New England and the North Coast, R. V. S. Wright, of the University of Sydney, was doing periodic excavations in the Hawkesbury-Broken Bay areas, while J. V. S. Megaw, also of the University of Sydney, was concentrating on the Botany Bay-Royal National Park region. The coast and ranges south of Wollongong were being systematically surveyed and excavated by members of the Australian National University in Canberra, under the direction of J. Golson.

This left only the Hunter River-Port Stephens area unconsidered, and so it seemed obvious that this was one gap the Australian Museum could fill. It had the great advantage that it was within easy reach, so that trips of only a few days or a week could be expected to achieve worthwhile results.

On studying the accounts of previous work in the Hunter Valley, it became apparent that virtually every side valley contained important relics and probably also occupation deposits. However, the Museum's project, as I saw it, should be strictly confined to the valleys of the Hunter and Goulburn Rivers, since the long-term objective was to attempt to reconstruct the prehistory of the valley peoples, both on the upper freshwater reaches and in the estuary. It seemed, therefore, essential not to be led away from the main objective up the interesting side valleys, otherwise little or no progress would be made on the main project. At the risk, then, of missing possibly more important sites in, for example, the Wollombi and Widdin Valleys, the survey has been concentrated on the main valley, with only brief excursions up the ancillary river systems.

In undertaking this archaeological survey and excavation of selected sites, the basic questions for which answers were sought were these:

(i) When was the valley first occupied?

(ii) What changes in culture, through time, could be recognized in the stratigraphic record?

(iii) What differences in basic tool-kit could be detected by a comparison of freshwater and estuarine assemblages in each period?

(iv) Were there any evidences in the archaeological record of the known historical contacts between the Hunter peoples and the adjacent tribes to their north, south, and west?

(v) How did the culture or cultures of the Hunter Valley compare with those already under investigation on the north and south coasts of New South Wales and with the situation on the inland river systems west of the Dividing Range?

The survey commenced in September 1965, when the upper Hunter between Belltrees and Muswellbrook was examined and considered archaeologically unpromising, the Goulburn Valley between Cox's Gap and Denman appeared more likely to be productive of sites, and the valley through the range from Sandy Hollow to Merriwa and Cassilis was found to provide easy access from the headwaters of the inland rivers into the upper Hunter Valley.

The area of the Hunter-Goulburn junction contained a multitude of steep conglomerate scarps with much undercutting, but detailed examination of many of these overhangs failed to reveal any sign of Aboriginal occupation. However, a number of large boulders fallen from these scarps contained considerable cavities forming caves and several of these were found to have occupation debris and artefacts scattered on the surface of the deposits within them. The most promising of these, situated adjacent to the Goulburn River, near the town of Sandy Hollow, and designated SH/1, was excavated between November 1965 and March 1966 and produced artefacts and food remains to a maximum depth of 3 feet 6 inches. It was clearly a flake and backed-blade industry, with the Bondi point predominating.

Attention was then turned to the Singleton area and, in particular, to the situation reported by McCarthy and Davidson (1943) and previously mentioned; that is, the erosion of large quantities of artefacts along the 200-foot contour at a number of points in the near vicinity of the Hunter southwest of Singleton. In an attempt to establish the exact provenance from which these artefacts were eroding, during June 1966 several series of test trenches were dug into the shallow topsoil at a number of points on the 200-foot terrace and produced small quantities of material similar to that surface-collected by McCarthy and Davidson. Close inspection of the Hunter banks and lower terraces, both above and below Singleton, failed to reveal any evidence of Aboriginal activity.

The next excavation was of an occupation deposit in a normal rock shelter (designated M/1) adjacent to a fine painted shelter on Bulga Creek at Milbrodale, on the southern fringe of the Hunter Valley. This deposit proved to be a shallow one, the deepest squares reaching the base rock shelf at 24 inches. Again this was a flake and backed-blade industry, with Bondi points and microliths occurring throughout. A second shelter in the same locality (M/2) was also excavated because a human mandible was found on the surface, but only a few fragments of bone and some flakes were found.

Before continuing the survey downstream to the Maitland-Cessnock area, it was decided to seek a site at the western outlet of the Cassilis Gap, since it was thought that this might provide useful comparative material and possibly throw further light on the upper Hunter industry. After survey in the area of Gulgong-Ulan-Cassilis, a small rock shelter on Bobadeen property (designated BOB/1), close to the source of the Goulburn River and almost on the watershed of the Divide, was excavated during March-June 1967. This proved to be an extremely productive deposit and again contained a flake and blade industry, with Bondi points and microliths throughout, though there were marked differences from the upper Hunter sites.

Sufficient material had now been obtained to commence an evaluation of the upper Hunter industry, and it was decided to finalize the analysis of all the material so far excavated and write a full report for publication, before proceeding to the second half of the survey on the estuarine part of the lower Hunter Valley. The remainder of this report, therefore, contains detailed descriptions of the sites excavated and the material identified, together with a comparative analysis of the artefacts obtained and a summary of findings up to this point. This first part of the Hunter Survey presents only basic data for the upper and central region of the valley. Detailed comparisons with relevant work elsewhere in eastern New South Wales will be made in the second half of the report, when the whole survey has been completed.

Before proceeding to the excavation reports, it is necessary to describe the system by which the implements were classified. It was decided that for the purposes of an extensive survey of this type it was desirable to utilize a fairly simple typology, but one which would enable comparison to be made with assemblages from other areas at an elementary level. After considerable study of the artefacts obtained from the sites so far excavated, it was decided to type them according to the following system:

Firstly, all BACKED BLADES are grouped together, but subdivided into Bondi; Elouera; Geometric Microlith; and Other (see plates 12, 14).

A variety of flakes with obtuse-angled cutting edges are classified as ADZE FLAKES. Although some of these resemble unused tulas, they could not be definitely classified as such, particularly as no tula slugs were found. However, all flakes included in the adze category show either retouch or work-use (see fig. 2).

The SCRAPERS, which include both flakes and blades with acute-angled cutting edges, are subdivided only into Side and End, according to whether the retouch and/or work-use are on the longer or shorter margin.

FABRICATOR (see fig. 1) was included as a main category, according to the definition of McCarthy (1946, 1967). Some tools of this type found in all three rock-shelter excavations had two opposing margins with the peculiar crushing work-use diagnostic for the type, but others had only one such edge. All such implements were included, since they were obviously used for similar purposes. It is possible that specimens with only one used margin are broken, so that the second edge is missing.

A variety of points were encountered, some uniface and resembling untrimmed pirris, others, mostly of quartz, like Bondis without backing, but showing signs of use. The category WORKED POINT was, therefore, subdivided into Point, Uniface, and Other (see figs 1, 2).

Numbers of amorphous UTILIZED FLAKES, without secondary working were encountered. These are subdivided into Blade and Other.

The remaining categories take care of all other tool types encountered in this particular region. Cores which showed work-use on any margin are included as implements under the heading CORE, UTILIZED; GROUND-EDGED AXES were found at Milbrodale and Bobadeen (see fig. 1). A number of natural pebbles, without flaking but showing signs of percussion or grinding are called PEBBLE, UTILIZED. Finally, a MISCELLANEOUS category is added for unidentifiable types which show undoubted signs of manufacture or utilization.

Waste flakes are divided into micro and macro categories, according to whether their maximum length falls below or exceeds 2 centimetres. Cores are similarly graded, with a maximum measurement of 3 centimetres as the dividing line.

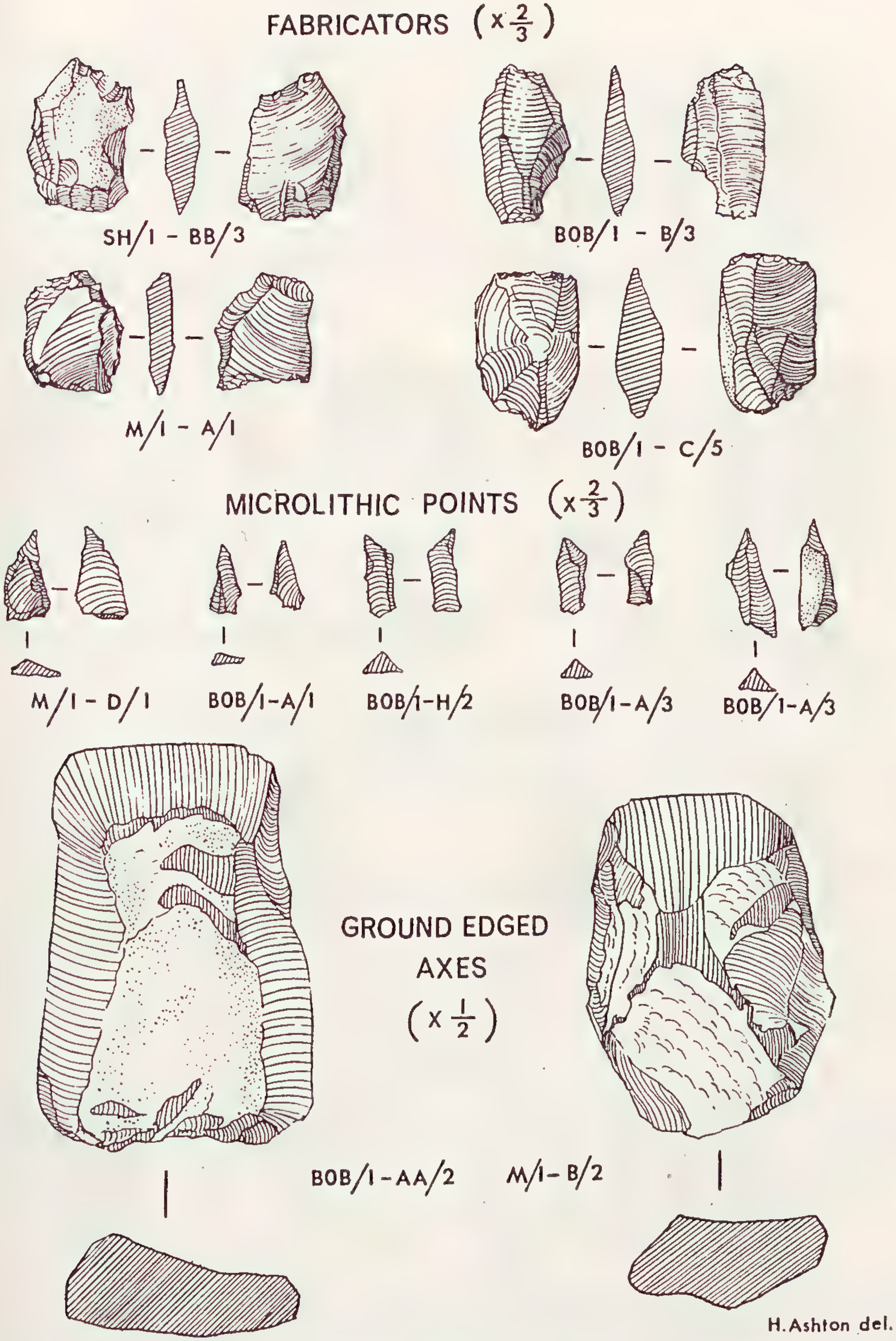


Figure 1: Implement types

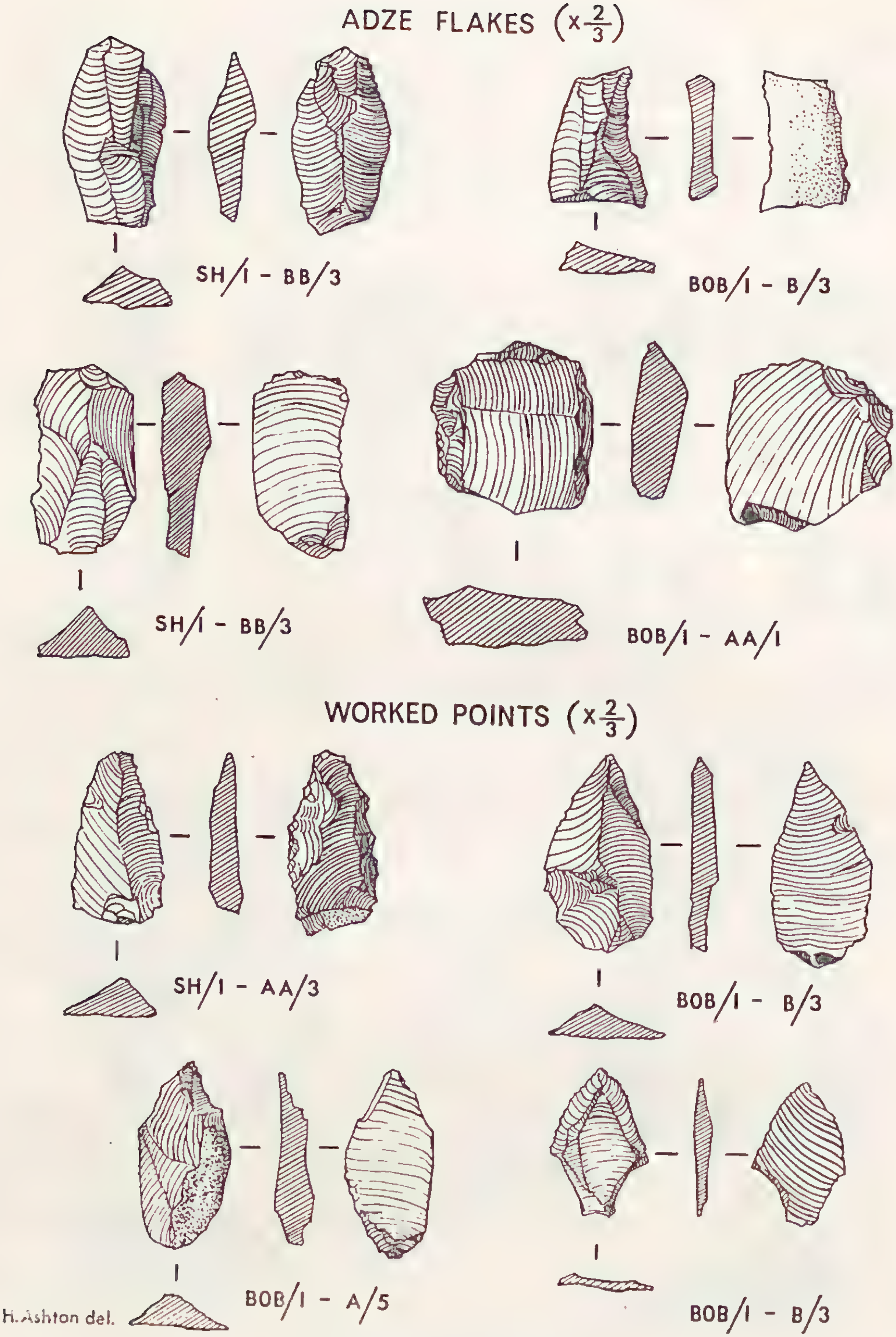


Figure 2: Implement types

THE EXCAVATIONS

Sandy Hollow (Map—Muswellbrook, 1 to 63360). See plates 4 and 5.

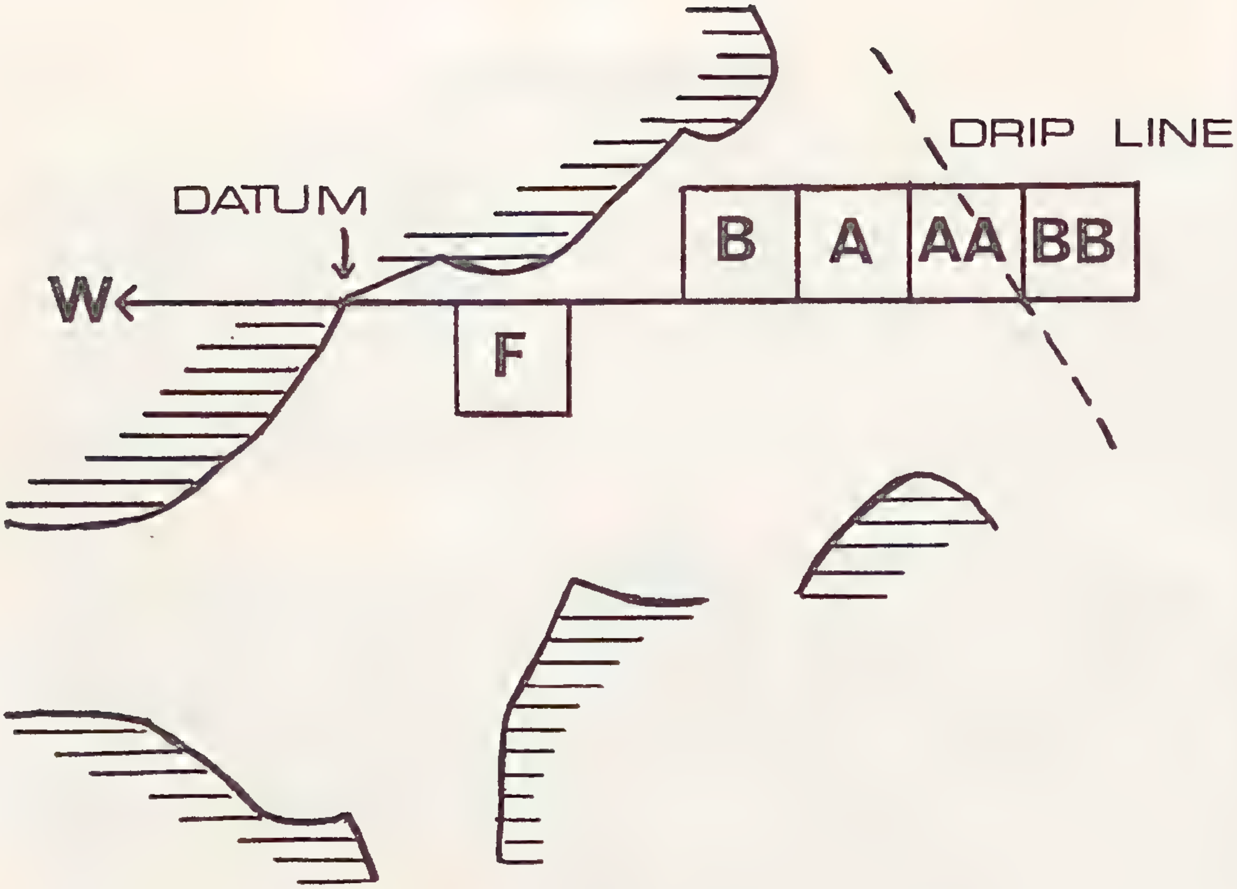
SH/1 rock shelter is situated at 531001, some 300 yards north of the Goulburn River at the foot of a rugged scarp, and consists of a huge hollow conglomerate rock lying in what is now a sloping paddock. Half a mile to the east, Halls Creek flows into the Goulburn, and it is the gorge cut through the scarp by Halls Creek that gives easy access into the valley which leads through the range to Merriwa and Cassilis. There is another cutting through the scarp about a mile to the west, where Worondi Rivulet joins the Goulburn; this also gives access to the Cassilis Gap. SH/1, therefore, is right at the point where the Gamilaroi from the western slopes would have reached the Hunter Valley system when they made their periodic excursions for trade, wives, or warfare with the Wonarua.

The method of excavation of SH/1 is shown in the accompanying ground plan and section (figs 3 and 4). In the absence of any continuous stratification, the excavation was carried out in 6-inch levels throughout. The main entrance to the shelter, which was the only one excavated, faces almost due east. There are subsidiary entrances on the western and southern sides of the rock and, as we dug in very hot weather, we found that these entrances, even though much diminished by the build-up of deposits, always channelled a cool breeze through the shelter. Also, the east entrance was pleasantly sunny and warm in the cool early morning, but shaded from the hot sun later in the day. Inside the cavity is a flat rock shelf, on which the whole rock shelter is resting, but this shelf ends just inside the east entrance, where a sort of natural seat is formed (in Square B).

Squares A and B contained almost exclusively implements and waste flakes, whereas Squares AA and BB, outside the dripline, produced quantities of bone, teeth, and shell, as well as artefacts. In these squares, rock slabs, fallen from an earlier extension of the overhang, were employed as fireplaces, augmented here and there by river boulders. The material in Square F, inside the shelter, was in loose dust and appeared to have been much mixed by the scuffling of animals; it has not been included in the statistical tables.

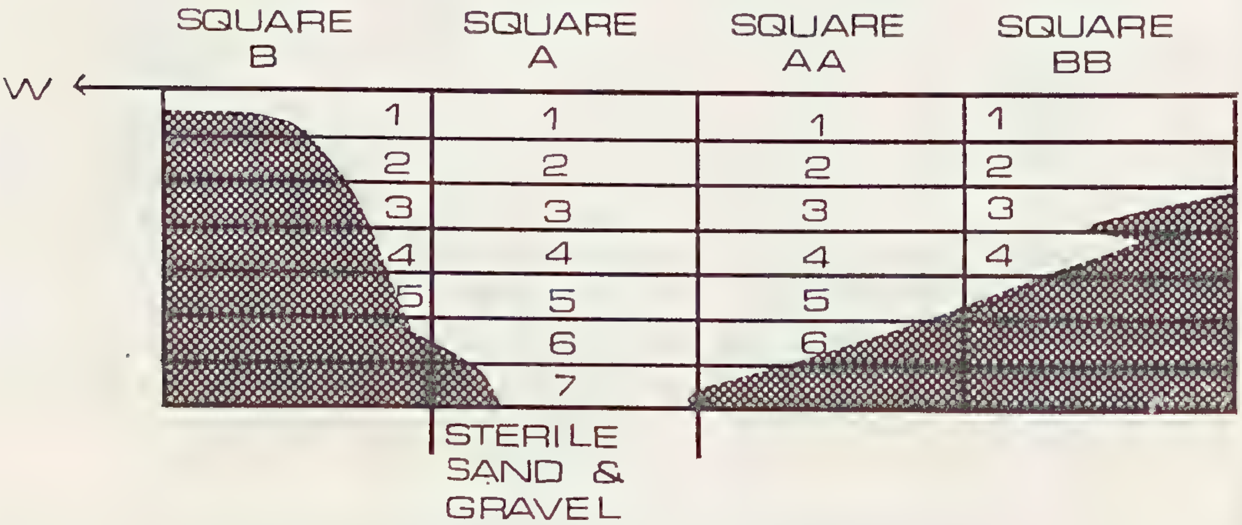
In Squares A and AA the excavation was taken into sterile yellow base sand at 3 feet 6 inches. Elsewhere base rock was encountered at varying depths. My initial interpretation of the site was that the rock shelf inside the shelter had been used as a sleeping place, the east entrance under the overhang as a workshop, and the cooking had been done in the hearths outside the front, so that the shelter was not filled with smoke when the nor'easter was blowing, and as the excavation progressed it seemed that this was correct. At first it seemed that the reason for the occupation of this particular site was that the inhabitants were making implements from the nodules in the conglomerate of which the rock is formed, but subsequently it became apparent that the material flaked had been obtained from the bed of the nearby Goulburn River, which was scattered with chunks of the yellow chert and red jasper that were the main materials used. The other material that appeared occasionally throughout the deposit was white quartz. Although no actual implements of quartz were found, a quantity of obvious waste flakes from quartz-working were present in all levels down to the bottom of Level 5.

The material from Sandy Hollow was subsequently sorted and roughly typed. Bondi points occurred only in the top four levels, the total for the whole excavation amounting to 66, together with a further 33 miscellaneous backed blades and 9 elouera. Waste flakes continued below Level 4, but the only implements present were a few scrapers and utilized flakes. The total of flakes and cores was 4190.



SANDY HOLLOW SHELTER NO.1 (SH/1)
LAYOUT OF SQUARES.
SCALE: 1/2" TO 3 FT.
DATUM E–W MAG.
MAP REF. MUSWELLBROOK – 531001.

Figure 3



SANDY HOLLOW SHELTER NO.1 (SH/1).
SECTION ALONG DATUM LINE.
SCALE: 1/2" TO 1 FT.

Figure 4

Table 1 shows the disposition of implements in the deposit, the size and location of waste flakes and cores, and the areas of occurrence of quartz. In Table 2 implements and waste are arranged by horizons.

The majority of the identifiable bones and jaws came from Square BB, Level 3, and all species noted still exist in the area. The main types are: Grey Kangaroo (*Macropus major*), several individuals represented; Wallaby (*Wallabia spp.*); and Brush-tailed Possum (*Trichosurus vulpecula*).

The shells present include *Alathyria profuga* (Gould); *Hyridella australia* (Lamarck); and *Cucumerunio novaehollandiae* (Grey). All these species are now classified in the family Hyriidae and are extant in the Hunter region.

Carbon-14 dates supplied by the Australian National University laboratory for charcoal from SH/1 were as follows:

ANU-125 Square BB, Level 1 (4–6 inches)—530±80 BP (A.D. 1420).
ANU-12 Square AA, Level 4 (23–24 inches)—1300±100BP(A.D. 650).

In the course of the Sandy Hollow excavation a reconnaissance was made of the Widdin Valley and a painted rock shelter at 337985 (Singleton—1 to 250,000), previously reported, was examined, photographed, and sketched. This shelter, also in a huge boulder, adjacent to Widdin Brook, had previously contained an extensive occupation deposit, but unfortunately this had been cut through by a realignment of the road some years before and, as a result, much material had fallen down and become intermixed. However, it was encouraging to learn that this shelter, known locally as "Black's Cave", had only been saved from total destruction by the strong representations of residents of the valley.

A number of other shelters with occupation deposits, similar to those at Sandy Hollow, were found higher up the Goulburn Valley, near Baerami, at 337994. The only other site located was on Hall's Creek, near Gungal, where the recent excavation of a dam at 510035 (Muswellbrook—1 to 63,360) showed yellow chert flakes in some quantity in the spoil thrown out by the bulldozer.

Singleton (Map—Singleton, 1–63360). See plates 6 and 7.

After the conclusion of the Sandy Hollow excavation, attention was concentrated on the Singleton area, particularly on the situation reported by McCarthy and Davidson (1943)—that is, the erosion of large quantities of artefacts along the 200-foot contour in the near vicinity of the Hunter southwest of Singleton. Starting from the Wollombi Brook junction and working down the Hunter to Singleton, artefacts were found in erosion points along the 200-foot contour at 046776, near Gouldsville (095734), Mount Thorley (105685), and particularly along a stretch of some hundreds of yards of what McCarthy termed the Gowrie terrace, from 145739 to 140724. Near Wylie's Flat on the high ground at 133722 both yellow chert and pink quartzite were found outcropping and there were signs that blocks had been struck off for making artefacts. On Reservoir Hill (150745) many artefacts were eroding out on and above the 200-foot contour.

In an attempt to clarify this situation, a number of test squares were dug at various points on the 200-foot terrace. The three main series, dug during June 1966, were designated and located as follows: S/1 was on the Gowrie terrace at 144727; S/2 was north of Gouldsville at 095734; and S/3 was on a reverse slope above a small creek at 135755. None of these trial excavations produced any conclusive evidence (nor any datable material), but they did establish that the artefacts eroding out were in fact contained in the sparse topsoil 6–12 inches deep, overlaying the heavy clay

Table 1. Sandy Hollow (SH/1): Distribution of Stone Implements, Waste, and Quartz

SQUARE		B					A							AA							BB					Grand Totals
LEVEL		1	2	3	4	5	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	
Blade Backed	Bondi	3	1	..	..	..	2	4	4	..	..	..	..	..	3	19	10	..	..	..	1	1	18	..	..	66
	Elouera	1	1	..	..	..	..	2	..	..	..	..	..	..	..	2	2	..	..	..	..	..	1	..	..	9
	Microlith	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	2	..	..	..	1	..	..	..	..	4
	Other	2	..	..	..	..	3	1	1	..	..	..	..	1	1	5	7	..	..	..	..	..	6	2	..	29
Scraper	Side	..	..	..	..	..	..	..	..	..	..	..	..	2	..	3	2	2	..	..	1	1	2	..	..	13
	End	..	..	..	..	..	..	..	..	..	..	..	..	..	1	2	..	1	..	..	..	..	..	..	..	4
Point, Worked	Uniface	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	..	2
	Other	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1	1	..	3
Flake Utilized	Blade	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	1	..	..	..	1	..	..	..	..	3
	Other	..	..	..	..	1	..	..	1	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	4
	Adze Flake	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	..	..	..	..	..	..	3	..	..	6
	Fabricator	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1
	Core, Utilized	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
	Axe, Ground-edged	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
	Pebble, Utilized	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
	Miscellaneous	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
Sub-Totals	Implements	6	2	0	0	1	6	7	6	1	0	1	0	3	5	37	24	3	0	0	4	2	33	3	0	144
CORE	Large	..	2	1	..	..	1	2	3	..	1	..	..	3	2	27	11	6	..	..	1	3	32	9	4	108
	Small	1	..	1	1	..	3	2	1	..	..	..	..	1	2	15	4	10	..	..	3	2	5	4	1	56
WASTE FLAKE	Large	43	22	5	18	7	37	77	63	15	11	10	..	24	36	345	162	158	2	1	15	29	211	54	38	1,383
	Small	171	116	37	50	19	147	171	148	43	20	33	1	157	81	331	272	232	3	1	67	61	210	75	53	2,499
Sub-Totals	Cores and Waste	215	140	44	69	26	188	252	215	58	32	43	1	185	121	718	449	406	5	2	86	95	458	142	96	4,046
Totals	Implements and Waste	221	142	44	69	26	194	259	221	59	32	44	1	188	126	755	473	409	5	2	90	97	491	145	96	4,190
Quartz	Implements	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
	Waste	19	7	1	5	1	10	3	5	4	1	2	..	11	9	41	11	12	..	..	5	7	1	2	..	157
Sub-Totals	Quartz	19	7	1	5	1	10	3	5	4	1	2	0	11	9	41	11	12	0	0	5	7	1	2	0	157

Table 2. Sandy Hollow (SH/1): Distribution of Implements and Waste by Horizons

Horizon	Blade, Backed				Scraper		Point, Worked		Flake Utilized		Adze Flake	Fabricator	Core, Utilized	Axe, Ground-Edged	Pebble, Utilized	Misc.	Core		Waste Flake		Totals
	Bondi	Elouera	Micro	Other	Side	End	Uniface	Other	Blade	Other							Large	Small	Large	Small	
1	6	1	1	6	3	..	..	..	2	..	..	..	..	..	..	..	5	8	119	542	698
2	9	3	..	2	1	1	..	..	..	..	..	..	..	..	..	..	9	6	164	429	624
3	41	3	1	12	5	2	2	2	..	1	6	1	..	..	..	..	63	22	624	726	1,511
4	10	2	2	9	2	..	..	1	1	1	..	..	..	..	..	..	20	9	249	440	746
5	..	..	..	..	2	1	..	..	..	1	..	..	..	..	..	..	11	11	214	324	564
6	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	12	36	49
7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	2	3
Totals	66	9	4	29	13	4	2	3	3	4	6	1	0	0	0	0	108	56	1,383	2,499	4,190

formations of which the body of the terrace was composed. No associated material was found, except that at S/1 glass fragments and a broken clay pipe were encountered in the top 3 inches. However, these were not necessarily associated with the Aboriginal artefacts, which generally did not occur in the top 4 inches of the deposits.

From personal communication with F. A. Davidson, formerly of Singleton, who collected extensively along the terrace in the early 1940's and aided McCarthy in his investigations in 1943, it seems that this topsoil, which is now held together by sparse grass, was formerly dry and dusty, so that in high winds considerable quantities were blown away. At that time the surface of the topsoil was scattered with artefacts, whereas now they are only found sticking in the underlying clay at erosion points. Probably the artefacts now present in the topsoil have accumulated there, owing to the wind and water erosion of the topsoil subsequent to the clearing of the trees by the early settlers. The establishment of grass cover may have caused some subsequent build-up of humus. In any case, it seems that the artefacts cannot be in an original matrix and are likely to be much mixed up.

When water erosion occurs today, artefacts are further accumulated by sticking in the clay at the erosion points. It is not, therefore, necessary to postulate an extraordinarily intensive implement-making industry on the terrace. It may be that the material comes from several periods, but is now inextricably mixed. It should be added that the only implements definitely identifiable in the material excavated on the 200-foot terrace are all geometric microliths, no Bondis or Eloueras being present, nor were any worked implements found during preliminary surface collecting at every erosion point visited. This, of course, may be due to the extensive surface collecting carried out by F. A. Davidson, and no doubt by others, over a number of years.

McCarthy and Davidson (1943) called the terrace industry an Elouean one, despite the fact that in the material they analysed there were 524 Bondi points and only 89 Eloueras.* Many of the artefacts in this material closely resemble those excavated at Sandy Hollow, but there are a number of types which were not represented at SH/1, for instance uniface pebble implements and a wide range of geometric microliths. Nor were the large flake tools of pink quartzite present at Sandy Hollow.

The 200-foot terrace is now in most places a windy, dusty exposed place and not at all attractive as a camp site, but when it was forested it was probably quite tolerable. However, the reason for the makers of the implements camping 50–100 feet above the river, and in most places up precipitous cliffs, is difficult to fathom. An initial explanation arrived at when surveying the area generally, was that perhaps at the time of this particular industry the Hunter was blocked at the point where it now cuts through the terrace between Mount Thorley and Hambledon Hill (122690) and that the whole of the area west of this point had been a lake up to 50 feet deep. In this case the occupants of the 200-foot terrace would have been camping around the shores of this lake. Alternatively, the Hunter might then have been considerably higher than it is now; there is evidence of considerable down-cutting and alteration of course in this area.

A third alternative was suggested by Dr David Branagan, of the Department of Geology, University of Sydney, who visited the area during the subsequent excavations at Milbrodale. He thought that possibly the geology of the 200-foot terrace had especially favoured the formation of the cherts and quartzites used in the industry and that the implement-making went on only at the level where the desired material was available. Certainly, there are outcroppings of both yellow chert and pink quartzite on the highest point of the terrace, directly above the river at 133732. McCarthy and Davidson (1943) stated that the raw material was obtained from the base of the terrace, where it occurred in the form of deposited pebbles.

---

* Subsequently McCarthy in 1948 redefined the term Eloueran to apply only to the upper phase at Lapstone Creek and has since used it in this sense only. The Singleton material is now Bondaian in his Eastern Regional Sequence.

Lloyd Hamilton, of the University of New South Wales, has drawn attention to a passage in H. G. Raggatt's (1938) unpublished D.Sc. thesis, which reads:

> In 1933, the writer exhibited photos . . . of extensive terrace gravels which occur about 100 feet above the present level of the Hunter River. These gravels have been largely changed to "grey billy" and it was suggested that the only possible explanation of the phenomenon was that they had been overlaid by basalts. These deposits may be seen at Abbey Green, 3 miles south of Singleton; in the village of Jerry's Plains; and on the Denman road, 10 miles from Muswellbrook.

Farther on Raggatt adds: "Confirmation of this has recently been supplied by J. A. Dalhunty (Proc.Roy.Soc. N.S.W. LXXI, 1938: 297–317) who has discovered basalt within the valley of the Goulburn". In this context Dalhunty states that he found basalt in the area where Munmurra Creek joins the Goulburn, i.e. between Kerrabee and Wollar. Raggatt further states: "Following peneplaination, the surface was uplifted and an extensive valley system carved out before the outpouring of the newer basalts. This last event happened in the not long distant past, the valleys having been only slightly modified since the extrusion of the newer basalts". He considers that there has been an uplift of about 100 feet since this laying down of the newer basalts.

This would seem to bear out the suggestion that the 200-foot terrace was a horizon where cherts and quartzites were most likely to form.

During the trial trenching of the 200-foot terrace a more intensive inspection of the Hunter banks above and below Singleton was carried out by the whole excavation party and artefacts were found eroding from the 200-foot contour at one other point (073749). No evidence whatsoever of Aboriginal occupation was found on the river banks and adjacent terraces between the Wollombi Brook junction and Singleton, nor for about 2 miles below Singleton towards Glendon.

Milbrodale (Map—Doyles Creek, 1–50,000). See plates 8 and 9.

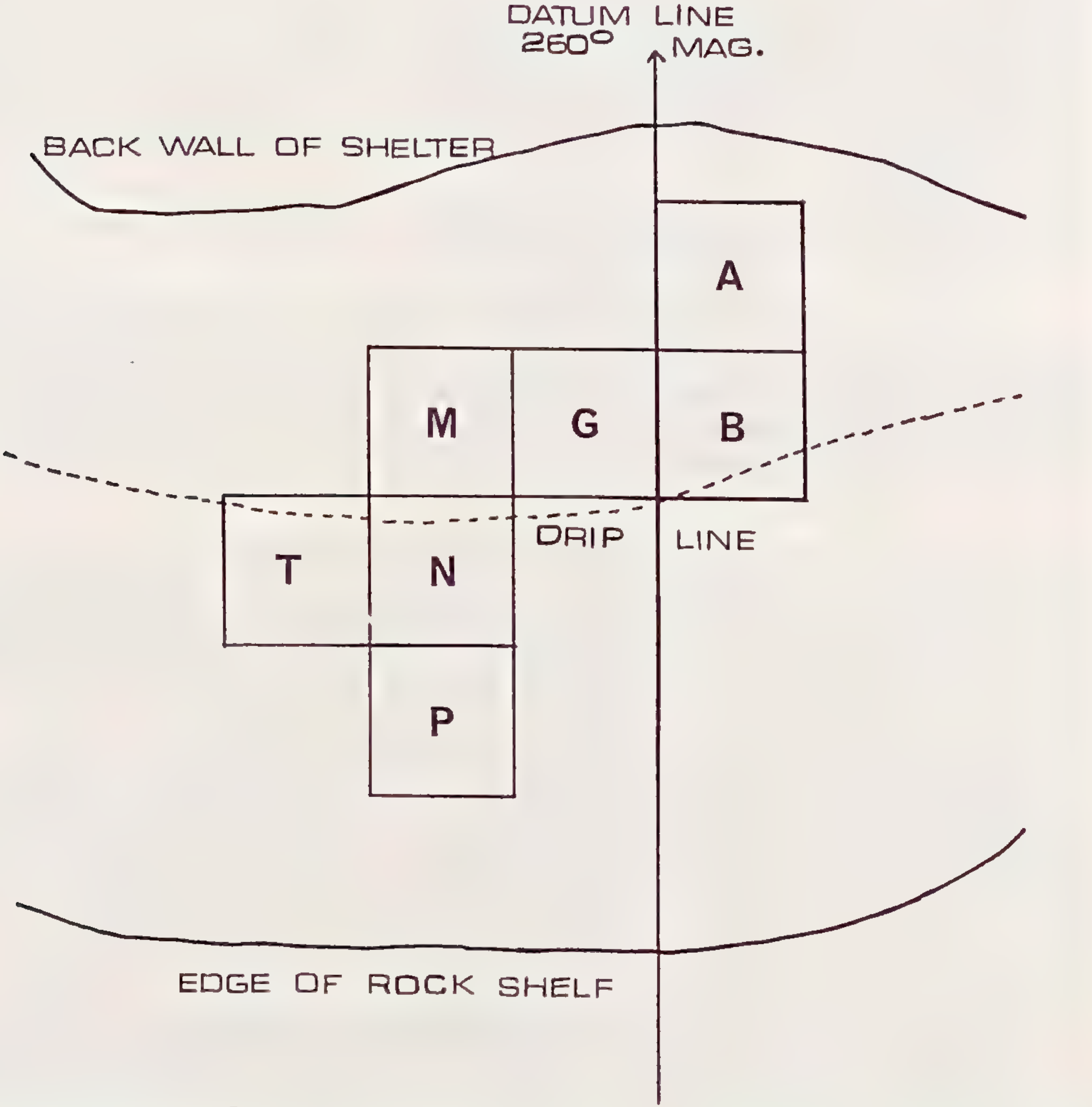
Rock-shelter M/1 at Milbrodale, which was the next site to be excavated, during November 1966, stands some 20 feet above the valley floor at the head of a small re-entrant overlooking Bulga Creek at 994566 and is the lower and larger section of a two-level shelter which faces eastwards.

The layout of the Milbrodale excavation may at first sight appear somewhat arbitrary (see fig. 5), but in fact it turned out to be a fairly shallow deposit, with a maximum depth of rather less than 2 feet, and the series of seven squares dug was an attempt to sample the areas likely to be deepest. Two teams excavated and sieved, the first starting with Square A and working forward into Square B, and the second team starting with Square M and working into N, P, and T. The connecting square, G (which included a 6-inch baulk and was therefore 3 feet by 3 feet 6 inches), was completed last by both teams.

The underlying rock shelf was very uneven and was overlain by many irregular slabs fallen from the roof. Some stratification appeared in Square M and was followed. In spite of these difficulties, the excavation was an interesting one and produced, in addition to the expected range of backed blades and utilized flakes, a fine pebble ground-edged axe (see fig. 1) in Level 2 of Square B, one quartz Bondi point and one quartz unbacked point, as well as a delicate microlith segment of chert in Level 1 of Square M. Bondis appeared in most of the top levels, but did not appear in the lowest levels, except in Squares M and T, which were only 18 inches deep. A total of 40 Bondi points was found in the whole excavation. A considerable amount of bone was encountered, especially along the drip-line, and some pieces seemed as if they might have been worked for points and scrapers.

Table 3 shows the disposition of implements, waste flakes, and quartz, which was most strongly represented in Level 2 in all squares, but extended throughout the excavated area. Table 4 groups implements and waste by horizons.

In the second shelter excavated at Milbrodale (M/2), which is situated near the fine painted shelter at 995569, a square approximately 6 ft x 4 ft was dug into loose white sand in 6-inch levels but produced only some odd flakes of chert and a few human and animal bones. It seems likely from the mandible originally found on the surface that the burial was in fact Aboriginal, but may well have been done in the post-settlement period, when many such burials with little or no ritual seem to



MILBRODALE SHELTER NO. 1. M/1. LAYOUT OF SQUARES.
SCALE: 1" TO 3'. MAP REF. DOYLE'S CREEK 994566.

Figure 5

Table 3. Milbrodale (M/1): Distribution of Stone Implements, Waste, and Quartz

SQUARE		A				B				G			M			N			P	T			Grand Totals
LEVEL		1	2	3	4	1	2	3	4	1	2	3	1	2	3	1	2	3	1	1	2	3	
BLADE, BACKED	Bondi	..	1	..	..	1	3	..	..	2	11	..	2	4	1	..	2	..	..	3	8	2	40
	Elouera	..	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
	Microlith	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	1
	Other	..	..	..	..	..	..	..	..	..	3	..	..	1	1	..	1	..	..	..	2	..	8
SCRAPER	Side	..	1	..	..	..	..	..	..	..	2	..	2	2	..	1	..	2	2	2	3	..	17
	End	..	1	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	1	1	..	4
POINT, WORKED	Uniface	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
	Other	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	2
FLAKE UTILIZED	Blade	..	1	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	2
	Other	..	..	..	..	..	1	..	..	1	..	..	..	1	1	..	..	..	..	1	..	..	5
	Adze Flake	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	1
	Fabricator	1	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	1	..	..	3
	Core, Utilized	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1
	Axe, Ground-edged	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
	Pebble, Utilized	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
	Miscellaneous	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
Sub-Totals, Implements		2	4	1	0	1	6	0	0	3	17	0	5	9	3	3	4	2	3	8	14	2	87
CORE	Large	..	..	..	..	1	4	..	..	..	1	..	..	5	2	..	5	..	1	5	6	..	30
	Small	9	6	2	1	2	13	8	1	6	10	..	2	8	1	3	7	2	..	20	21	..	122
WASTE FLAKE	Large	14	23	1	1	11	24	8	2	26	42	1	24	50	8	14	53	12	9	46	77	..	446
	Small	55	62	9	..	75	86	38	7	84	165	15	70	182	39	37	89	29	31	102	157	6	1,338
Sub-Totals, Cores and Waste		78	91	12	2	89	127	54	10	116	218	16	96	245	50	54	154	43	41	173	261	6	1,936
Totals, Implements and Waste		80	95	13	2	90	133	54	10	119	235	16	101	254	53	57	158	45	44	181	275	8	2,023
QUARTZ	Implements	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	1	..	..	..	2
	Waste	2	4	1	..	6	9	4	..	3	10	..	1	18	2	1	20	1	2	22	17	..	123
Sub-Totals, Quartz		2	4	1	0	6	9	4	0	3	11	0	1	18	2	1	20	1	3	22	17	0	125

Table 4. Milbrodale (M/1): Distribution of Implements and Waste by Horizons

Horizon	Blade, Backed				Scraper		Point, Worked		Flake Utilized		Adze Flake	Fabricator	Core, Utilized	Axe, Ground-Edged	Pebble, Utilized	Misc.	Core		Waste Flake		Totals
	Bondi	Elouera	Micro	Other	Side	End	Uniface	Other	Blade	Other							Large	Small	Large	Small	
1	8	. .	1	. .	7	2	. .	2	. .	2	. .	2	1	. .	. .	. .	7	42	144	454	672
2	29	1	. .	7	8	2	. .	. .	2	2	1	1	. .	1	. .	. .	21	65	269	741	1,150
3	3	1	. .	1	2	. .	. .	. .	. .	1	. .	. .	. .	. .	. .	. .	2	13	30	136	189
4	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	2	3	7	12
Totals	40	2	1	8	17	4	0	2	2	5	1	3	1	1	0	0	30	122	446	1,338	2,023

have been carried out as the tribal life broke down. The shelter had been well routed through by animals or human beings, and probably the rest of the skeleton and the skull have long ago been dispersed.

Carbon dates from M/1 are as follows:

ANU-121 Square A, Level 1 (4–6 inches)—630 ± 60 BP (A.D. 1320).

ANU-122 Square G, Level 2 (6–12 inches)—1410 ± 90 BP (A.D. 540).

These accord well with the time-span of occupation at SH/1.

Bobadeen (Map—Dubbo, 1–250,000). See plates 10 and 11.

The BOB/1 shelter, which was excavated during May and June 1967, is located at 274022, beside Queens Creek, almost on the watershed of the Great Dividing Range and near the source of the Goulburn River. About a mile away, at 274018, is a magnificent painted rock shelter containing a frieze of red hand-stencils about 300 feet long. The floor of this huge shelter, though containing artefacts, has been much interfered with, both by human agency and by water. BOB/1, although a very small shelter, about 14 feet long and 9 feet deep, produced a remarkable quantity of implements and waste, the total artefacts amounting to 16,609, of which 907 were implements. The material used differed considerably from that of the upper Hunter, since it included a high proportion of milky-white quartz and rock crystal, together with a very fine-grained grey chert. Bondi points were again prominent throughout. In addition, 69 probable bone implements were identified, including 42 of what appears to be a specialized type resembling a burin, whose use can only be a matter for speculation (see plate 13). It is possible that they may have been scribers, used for making the line decorations on marsupial-skin cloaks, one of which from this area is described by Mountford (1963). These presumptive bone implements occurred in all squares in levels 1–3. A bone spatula was found in Square A, Level 2.

The final form of the excavation was a cross (see fig. 6), which gave a good section from back wall to front spill and also followed the dripline to the farthest possible limit. The occupation deposits went down to a maximum depth of 48 inches, when hard grey sterile clay was encountered along the dripline, but within the shelter, in Squares A and AA, a sandstone floor was met with at 30 inches, while in Square AA a shelf was found projecting from the back wall at about 6 inches depth and extending out for about 9 inches (see fig. 7).

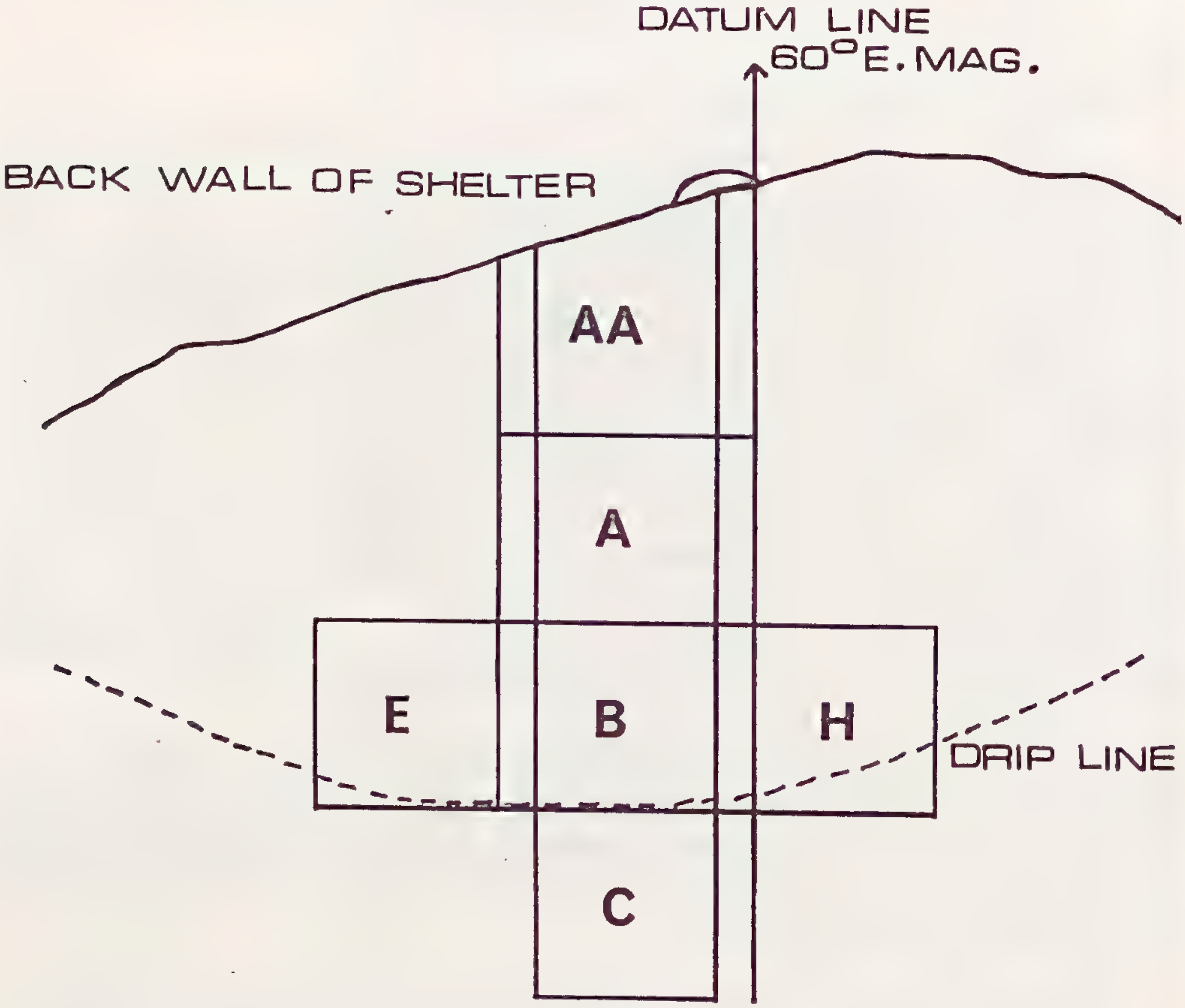
Squares E, B, and H, which were bisected by the dripline, and Square C outside, contained two rather puzzling layers of what appeared to be a very hard, brown, compacted clay and grit, at depths of about 12 inches and 18 inches. Between these layers was a dark brown humus, similar to the surface deposit, and below them was a fairly compacted yellow gravel. The two compacted layers and the area between them were most prolific of artefacts (see plate 11).

Within the shelter, in Squares A and AA, the only stratification was the change-over from surface brown humus to yellow gravel in Level 3, at about 15 inches depth. In front of the shelter, in Square C, we encountered the usual piled slabs of sandstone, obviously fallen from an earlier overhang, and these extended in places up to the present dripline.

A broken cutting edge of a ground-edged axe was found in Square E, Level 2, and in Square AA, Level 2, were a complete pebble axehead (see fig. 1), a pebble hammerstone, and a small pebble muller.

The extraordinary quality of the quartz-working at this site surprised all those excavating. Quartz Bondis ranged from perfect specimens to rough stubby blades, but some of the quartz crystal geometric microliths, many less than a centimetre in length, could scarcely be believed to be man-made, until they were placed under a medium-powered microscope, when it could be seen that there was unquestionable secondary working along their backs (see plate 14).

The disposition of implements and waste, and the proportion of quartz in each level, are shown in Table 5. It will be noticed that Bondi points appear consistently,

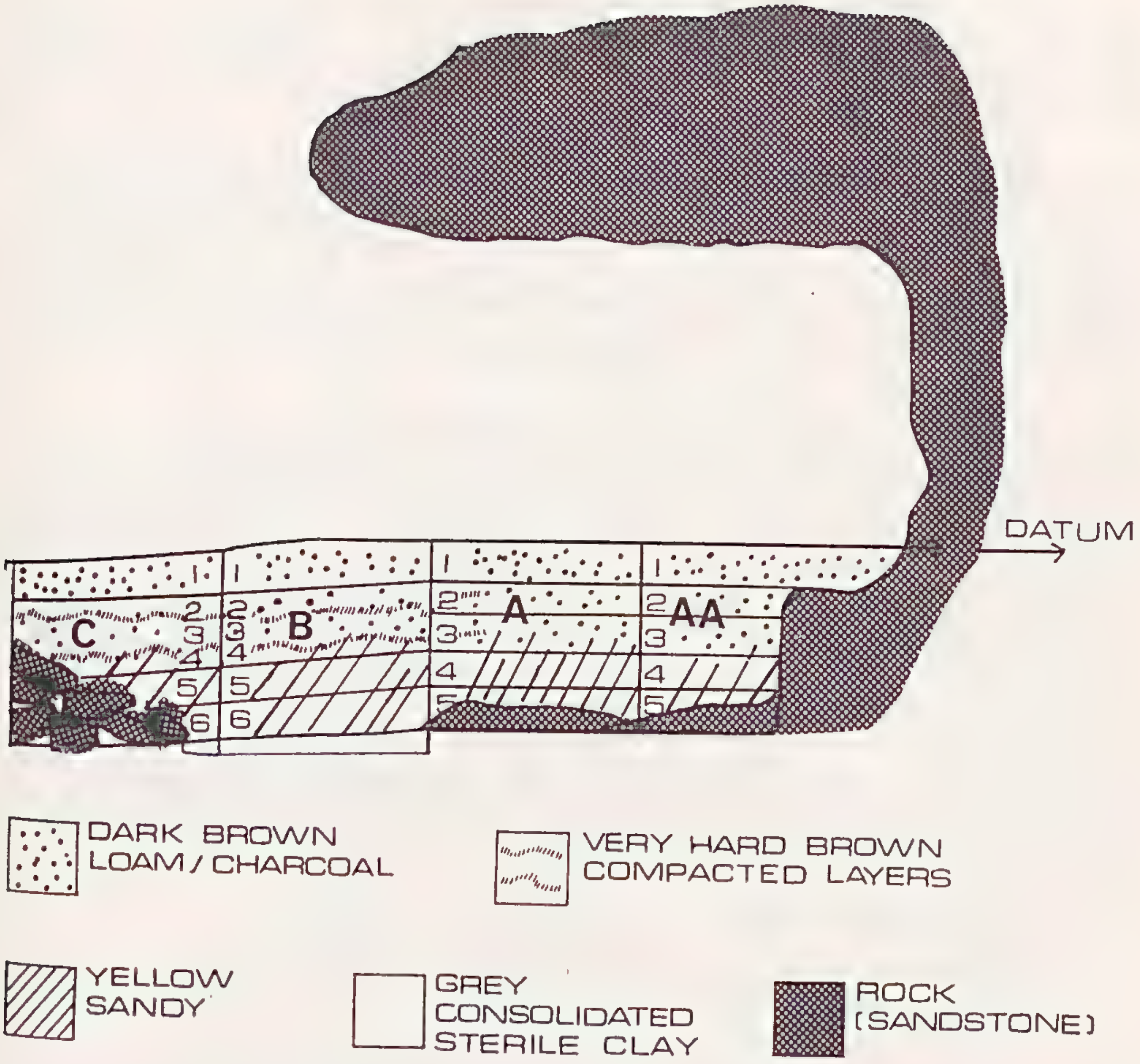


BOBADEEN SHELTER NO.1. BOB/1.
LAYOUT OF SQUARES.
SCALE: 1" TO 3'. MAP REF. DUBBO
1 TO 250,000 —— 274022.
NOTE: SQ.B INCLUDED BAULKS OF 6" ON
EITHER SIDE, MAKING AN ADDITION OF
1'X 3'. SQ.AA INCLUDED TRIANGULAR
SECTION AGAINST ROCK WALL, 3'X 9".

Figure 6

Table 5. Bobadeen (BOB/1): Distribution of Stone Implements, Waste, and Quartz

SQUARE		A					AA					E								H				C						B					Grand Totals
LEVEL		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	6	7	8	1	2	3	4	1	2	3	4	5	6	1	2	3	4	5	
Blade, Backed	Bondi	8	14	..	..	..	6	8	3	1	..	7	11	3	11	9	3	1	..	3	20	12	5	5	14	9	14	2	2	5	21	28	24	..	249
	Elouera	..	1	..	..	..	6	2	..	1	..	1	2	..	4	4	..	..	..	..	5	..	..	4	3	3	..	..	1	3	2	3	2	..	47
	Microlith	2	8	..	1	..	3	3	3	..	..	..	3	1	1	4	2	1	2	2	9	1	1	3	1	5	2	3	..	2	5	15	8	..	91
	Other	..	7	1	1	..	3	8	..	..	..	2	8	2	7	1	1	..	..	1	16	1	3	9	8	3	4	4	..	7	13	15	5	2	132
Scraper	Side	2	5	3	..	..	10	..	..	1	..	4	15	1	3	..	..	..	..	8	6	1	..	4	7	1	5	3	..	4	10	2	2	2	99
	End	..	5	..	..	..	..	9	1	1	..	..	4	1	1	1	..	..	..	3	4	4	1	..	8	2	3	1	..	5	6	4		..	67
Point, Worked	Uniface	1	2	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	6
	Other	1	3	2	..	1	5	2	..	..	..	1	1	..	3	..	..	1	..	1	5	1	..	..	1	..	2	1	..	4	4	3	..	..	42
Flake, Utilized	Blade	..	2	..	..	..	..	3	2	..	..	2	5	1	2	2	..	..	..	1	8	1	..	1	4	2	3	..	4	..	1	5	..	1	50
	Other	..	..	..	2	..	1	1	..	1	..	..	1	1	1	..	..	..	..	..	1	..	..	..	2	..	..	2	1	..	5	1	2	..	22
	Adze Flake	2	2	..	..	..	2	..	1	..	..	1	..	..	..	..	..	..	..	2	..	1	..	2	..	..	..	..	..	1	5	1	2	..	22
	Fabricator	1	..	1	..	..	2	2	..	1	..	..	2	..	1	..	..	..	..	2	1	..	..	2	4	..	..	1	..	..	10	1	2	..	33
	Core, Utilized	4	..	..	..	..	..	1	1	..	..	1	2	..	2	..	..	..	..	1	3	..	..	2	..	..	..	4	..	1	..	..	..	..	22
	Axe, Ground-edged	..	..	..	..	..	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
	Pebble, Utilized	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	3
	Miscellaneous	3	5	..	..	..	1	2	..	..	..	1	..	..	1	..	..	..	..	..	4	..	1	1	1	..	..	..	..	..	..	..	..	..	20
Sub-Totals, Implements		24	54	7	4	1	39	44	11	7	0	20	55	10	37	21	6	3	2	24	82	22	11	33	53	25	33	21	8	32	83	80	50	5	907
Core	Large	2	2	1	0	0	0	0	3	0	0	1	0	0	2	1	1	1	..	0	5	2	0	2	16	..	15	10	1	0	1	1	8	..	75
	Small	3	6	2	1	1	4	6	5	2	0	3	7	2	6	11	2	2	..	4	8	2	0	4	20	2	7	7	3	3	20	5	21	6	175
Waste Flake	Large	45	119	25	5	0	68	73	28	10	1	65	142	43	112	68	25	18	6	37	140	55	19	76	87	50	60	67	18	85	157	119	73	4	1,900
	Small	298	531	214	95	11	686	830	252	138	3	262	948	143	442	537	341	211	62	601	1,000	373	339	558	615	197	318	380	106	766	907	537	813	38	13,552
Sub-Totals, Cores and Waste		348	658	242	101	12	758	909	288	150	4	331	1,097	188	562	617	369	232	68	642	1,153	432	358	640	738	249	400	464	128	854	1,085	662	915	48	15,702
Totals, Implements and Waste		372	712	249	105	13	797	953	299	157	4	351	1,152	198	599	638	375	235	70	666	1,235	454	369	673	791	274	433	485	136	886	1,168	742	965	53	16,609
Quartz	Implements	11	17	3	1	..	13	7	4	4	..	4	13	3	10	5	3	1	2	7	22	6	4	4	18	5	11	10	4	9	33	22	23	2	281
	Waste	150	358	164	69	8	511	599	211	116	2	124	536	101	380	416	272	168	36	288	803	291	219	321	395	139	256	246	37	204	443	372	528	26	8,789
Sub-Totals, Quartz		161	375	167	70	8	524	606	215	120	2	128	549	104	390	421	275	169	38	295	825	297	223	325	413	144	267	256	41	213	476	394	551	28	9,070


DATUM
C
B
A
AA
1
2
3
4
5
6
DARK BROWN LOAM / CHARCOAL
VERY HARD BROWN COMPACTED LAYERS
YELLOW SANDY
GREY CONSOLIDATED STERILE CLAY
ROCK (SANDSTONE)

BOBADEEN SHELTER 1. SECTION OF SQUARES ALONG DATUM LINE. SCALE ½" TO 1'. MAP REF. DUBBO 1 TO 250,000 – 274,022.

Figure 7

except in Square A, where there were none below Level 2. The spread of microliths also is fairly even. The industry, in fact, is uniform throughout the deposit and is markedly a Bondaian one, showing a very high standard of workmanship. Table 6 shows implements and waste by horizons.

Charcoal was found in most levels, but bone occurred only in Levels 1–3. A somewhat puzzling feature is that rabbit or hare bone was found in Level 2 in Squares A, AA, B, and E, while there was a hare or rabbit jaw in Square A, Level 3. Sheep bones were found in Level 2 of Squares E and H. There was no sign that the deposits had been interfered with in any way, nor was there anything to indicate the previous existence of burrows. There were root systems along the top of the first compacted layer, but these did not extend into Square A. In the light of the carbon dates given below, it can only be assumed that these post-European bones are intrusive, having been trodden into the deposit, or else are the result of burrows now completely disappeared.

Apart from these obviously recent bones the chief animals represented (in the top three levels only) were bandicoot, Ringtail Possum (*Pseudocheirus*), Brushtail Possum (*Trichosurus*), wallaby (*Wallabia*), and rat kangaroo (*Bettongia*). Freshwater shells appeared in the top three levels and there were 132 fragments of emu eggshell.

The problem of the compacted layers requires some discussion. They were very rough and uneven and certainly not consonant with any possible flood deposition. In any case, the area as it is today is extremely unlikely to suffer flooding. Queens Creek rises only a mile to the northwest, near the watershed of the Divide, and is dry for most of the year. Before the tree cover was cleared it may have run more consistently, but it lies about 30 feet below the shelter and has cut down only moderately below the level of the paddock. The country is gently rolling, with sandstone outcrops, and has a general inclination towards the Goulburn.

Analysis of samples taken from the compacted layers was carried out by the Chief Chemist, Department of Agriculture, N.S.W., who identified the material as "Sandy clay loam" with a pH of 6.9. He suggests that "the compacted material represents deposits from times of occupation of the shelter and that its organic layers represent times of non-occupation. The irregular surface could be due to the formation of large roots, but alternatively the roots could have preferentially travelled along existing depressions in the material". The impression given by the compacted layers in situ was that the marked uneveness could not have been caused by roots, but was an intrinsic part of the original deposition. It is possible that these two compacted layers are the result of exceptionally rainy periods during which there was extensive run-off of water and sand from the sandstone plateau above the shelter. It is noteworthy that the compacted layers extended only to the inner edges of Squares E, B, and H and were not found in Squares A and AA. The present conformation of the ground is such that run-off from the plateau tends to pass across the front of the shelter before being diverted down to Queens Creek.

Carbon dates from BOB/1 are as follows:

ANU-123 Square E, Level 1 (4–6 inches)—730 ± 70 BP (A.D. 1220).

ANU-124 Square E, Level 7 (25–30 inches)—7750 ± 120 BP (5800 B.C.).

If these dates are compared with the artefact yields shown in Table 3, it will be seen that ANU-124 is apparently associated with the lowest Bondi point obtained from Square E. If this is the case, the date (5800 B.C.) would be an exceptionally early one for the start of the Bondaian industry. However, Level 7 was 6 inches in depth and it is possible that the solitary Bondi came from the top of the level, whereas the majority of the scattered charcoal flakes constituting the sample for dating may have been obtained from the lower part of the level.

In an effort to clarify this situation, during July 1968 a further sampling was made by extending Square E for a distance of one foot on its eastern and western sides. The levels in these areas correlating with Levels 7 and 8 in Square E were excavated in 2-inch sub-levels and sufficient charcoal for dating was obtained from each 2-inch sub-level. At the time of going to press only one of these had been processed:

ANU-287 Square E, Level 7 (25–26 inches)—5150 ± 170 BP (3200 B.C.).

Artefacts obtained from these extensions included one Bondi point from the top 2 inches of Level 7 and microliths and unbacked points down to the top 2 inches of Level 8. Below this, sterile clay and gravel were encountered, as in Square E itself.

Table 6. Bobadeen (BOB/1): Distribution of Implements and Waste by Horizons

Horizon	Blade, Backed				Scraper		Point, Worked		Flake Utilized		Adze Flake	Fabricator	Core, Utilized	Axe, Ground-Edged	Pebble, Utilized	Misc.	Core		Waste Flake		Totals
	Bondi	Elouera	Micro	Other	Side	End	Uniface	Other	Blade	Other							Large	Small	Large	Small	
1	34	14	12	22	32	8	1	12	4	1	10	7	9	..	..	6	5	21	376	3,171	3,745
2	88	15	29	60	43	36	2	16	23	10	7	19	6	2	3	12	24	67	718	4,831	6.011
3	55	6	25	22	8	12	2	6	11	2	3	2	1	..	..	..	7	18	320	1,716	2,216
4	55	7	13	20	11	9	1	5	5	6	2	4	2	..	..	2	25	37	279	2.145	2,628
5	11	4	7	7	5	2	..	2	3	2	..	1	4	..	..	..	11	25	140	969	1,193
6	5	1	2	1	..	..	..	..	4	1	..	..	..	..	..	..	2	5	43	447	511
7	1	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	1	2	18	211	235
8	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	62	70
Totals	249	47	91	132	99	67	6	42	50	22	22	33	22	2	3	20	75	175	1,900	13,552	16,609

COMPARISON OF SITES

General Implements and Waste

The accompanying histograms (Fig. 8) show visually the occurrence of the chief implement types and waste at the three main sites excavated—Sandy Hollow (SH/1), Milbrodale (M/1), and Bobadeen (BOB/1). The histograms of implement types represent percentages of total implement yields. Cores and waste flakes are percentages of total waste material. Each vertical division in each column on the chart represents 5 per cent. Cores are graded into small (less than 3 cms maximum measurement) and large (> 3 cms), waste flakes into small (less than 2 cms maximum length) and large (> 2 cms).

The first point that emerges from this visual comparison is that the backed blade industry at Bobadeen was a more generalized one than that of the upper Hunter, since the Bondi points form a considerably smaller component in it than at either Sandy Hollow or Milbrodale. The second obvious difference is that micro flakes predominate in the waste material at Bobadeen to a far greater degree than at the upper Hunter sites. This is most likely a reflection of the fact that the Bobadeen industry is more markedly microlithic than the others, but probably also reflects the much higher percentage of quartz implements and waste at Bobadeen. Table 7 shows this clearly.

Table 7. Comparison of Implements to Waste

	Sandy Hollow SH/1	Milbrodale M/1	Bobadeen BOB/1
Implements (Total)	144	78	907
Cores (Total)	164	152	250
Waste flakes (Total)	3,882	1,784	16,143
Impls/Waste (%)	3·5	4·0	5·5
Quartz impls (Total)	..	2	281
Quartz waste (Total)	157	123	8,889
Quartz impls/Total impls (%)	..	2.6	31
Quartz waste/Total waste (%)	3·7	6.8	55
Quartz impls/Quartz waste (%)	..	1.5	3·1
Non-quartz impls/Non-quartz waste (%)	3·7	4·6	9·2

The difference between the ratio of quartz implements to quartz waste and that between non-quartz implements and non-quartz waste at Bobadeen shows clearly the greater difficulty in fashioning quartz. Comparison between the ratios for Bobadeen and Milbrodale would probably not be valid, since the sample of quartz implements from Milbrodale was so small. However, when one compares the ratios of total implements to total waste for the three sites, the greater overall efficiency of the Bobadeen industry is apparent, particularly in view of the high percentage of quartz at Bobadeen. The difference is even more marked when the ratios for non-quartz implements are compared.

The greater intensity of material in the Bobadeen shelter is immediately apparent from the figures given in Table 8.

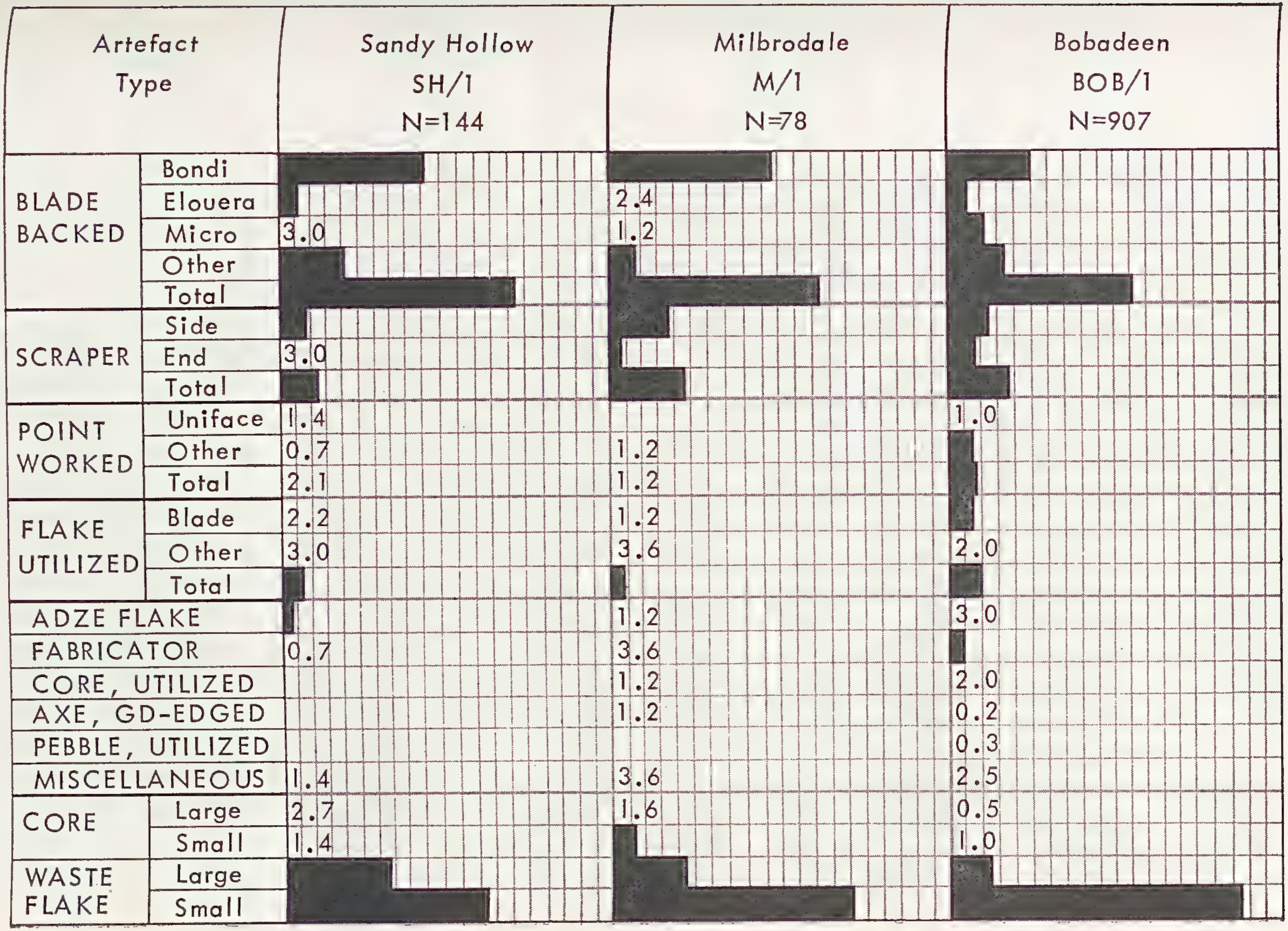


Fig. 8. COMPARATIVE OCCURRENCE OF ARTEFACTS (%)

Table 8. Yield of Implements and Waste

	Sandy Hollow	Milbrodale	Bobadeen
	SH/1	M/1	BOB/1
Approx. vol. excavated (cu. ft)	90	60	140
Yield per cu. ft (impls and waste)	47.2	33.6	120.6
Yield per cu. ft (impls only)	1.6	1.3	6.5

Bondi Points

Turning now to a more intensive examination of the type tool of each of the three sites—the Bondi point—some general comparative statistics will give a picture of the relation of the Bondis to the remainder of the implements and to waste at each site; some figures relating to quartz Bondis are also included.

Table 9. Comparison of Yield of Bondi Points

	Sandy Hollow SH/1	Milbrodale M/1	Bobadeen BOB/1
Bondi points (Total)	66	40	221
Bondi/total impls (%)	42	49	23
Bondi/waste (%)	1.6	2.0	1.4
Quartz Bondi (Total)	..	1	95
Quartz Bondi/Bondi (%)	..	2.5	43
Quartz Bondi/Quartz waste (%)	..	0.8	1.7
Non-quartz Bondi/non-quartz waste (%)	1.7	2.1	1.5

It will be noticed that, in the figures for Bobadeen, unlike the ratios for implements in general, the percentages for Bondis might be taken to imply that production of Bondis from quartz was more efficient than that from other materials. However, this may be merely a reflection of the fact that the proportion of Bondis to backed blades as a general class was considerably lower at Bobadeen than at the other two sites, whereas the proportion of quartz Bondis to non-quartz Bondis was high.

Measurements on whole Bondis were carried out as follows:

Maximum length—from tip to butt
Maximum breadth—wherever on the blade this occurred
Thickness—at mid point between tip and butt
Cutting angle—at mid point

Measurements were made by caliper, with vernier, to the nearest millimetre and by steel adjustable protractor to the nearest degree. The following table gives a comparison of the means of the measurements for Bondis from each site.

The only marked variation in these figures is that at Bobadeen the mean length of Bondis is considerably lower than that for the other sites. This again may be merely a reflection of the high proportion of chunky quartz blades made. This factor is reflected also in the means for weight and for breadth/length ratio.

Table 10. Comparative Mean Measurements of Bondi Points

	Sandy Hollow SH/1 N = 58	Milbrodale M/1 N = 28	Bobadeen BOB/1 N = 197
Length (cm)	2.5	2.27	1.9
Breadth (cm)	0.7	0.74	0.72
Thickness (cm)	0.4	0.39	0.37
Cutting angle (° at mid-point)	36	40	33
Weight (gm)	0.7	0.7	0.6
Breadth/length ratio (L = 100)	31	34	40

The mean cutting angle for the Milbrodale Bondis seems to imply some technological differentiation. In case it might be thought that this figure was affected by a few aberrant specimens, it should be added that the median for cutting angle for Milbrodale was even higher, 40.75°, while that for Sandy Hollow was 36.50°. The single quartz Bondi from Milbrodale had a cutting angle of 50°, but 15 chert specimens also had cutting angles in excess of 40°, while two of the chert specimens had a cutting angle the same as the quartz one. In general, it seems that the Milbrodale people preferred a more obtuse-angled backed blade than did the craftsmen at the other two sites.

The next table refers to the work use and retouch found on the chords of Bondis from all three sites.

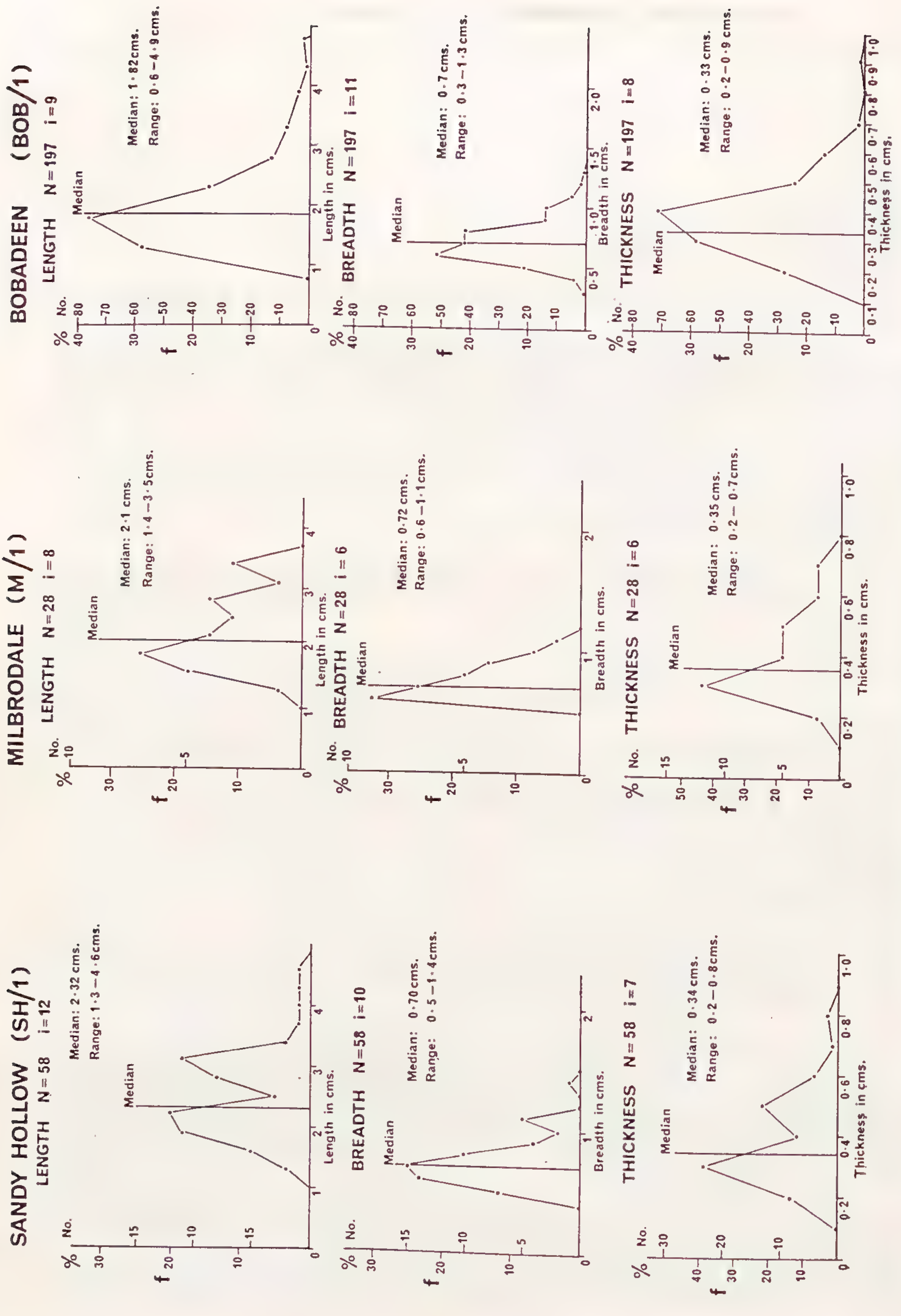
Table 11. Comparison of Bondis with Work-Use

	Sandy Hollow SH/1	Milbrodale M/1	Bobadeen BOB/1
Bondi with work use/retouch	9	6	40
Used Bondi/Total Bondi (%)	13.7	15	18

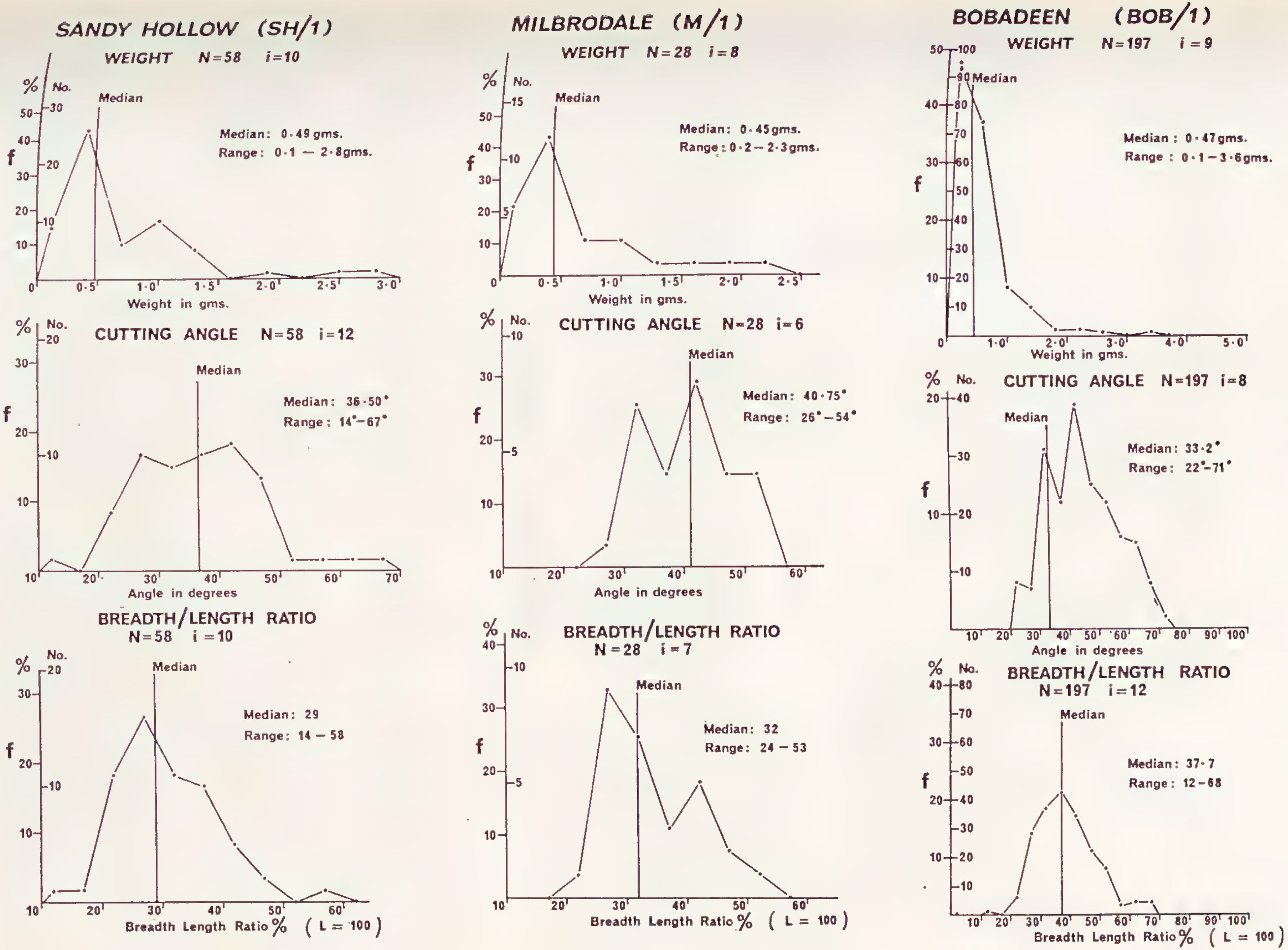
The percentages of Bondis with work-use are reasonably consistent for the three sites and would seem to imply that, for this area at least, the Bondi was employed as a cutting instrument with some regularity.

The frequency distributions of the various characteristics measured on the total whole Bondi points from each excavation site are shown graphically in the following series of comparative frequency polygons (figs 9–26). It should be noted that the marked difference in the sizes of the samples from the three sites encourages some exaggeration of the tendencies illustrated. Nevertheless, a number of obvious variations call for comment.

Firstly, the variation in average length already shown in the table of means (Table 10) is endorsed by the first three polygons (figs 9–11), but the bimodalism of the SH/1 polygon is surprising. This tendency may also be reflected in the M/1 curve, which has a small second peak at 3 cms. It is certainly absent in the BOB/1 polygon, which shows only one peak in what is nearly a perfect bell-curve



Figures 9–17. Comparative Frequency Polygons: Bondi Points



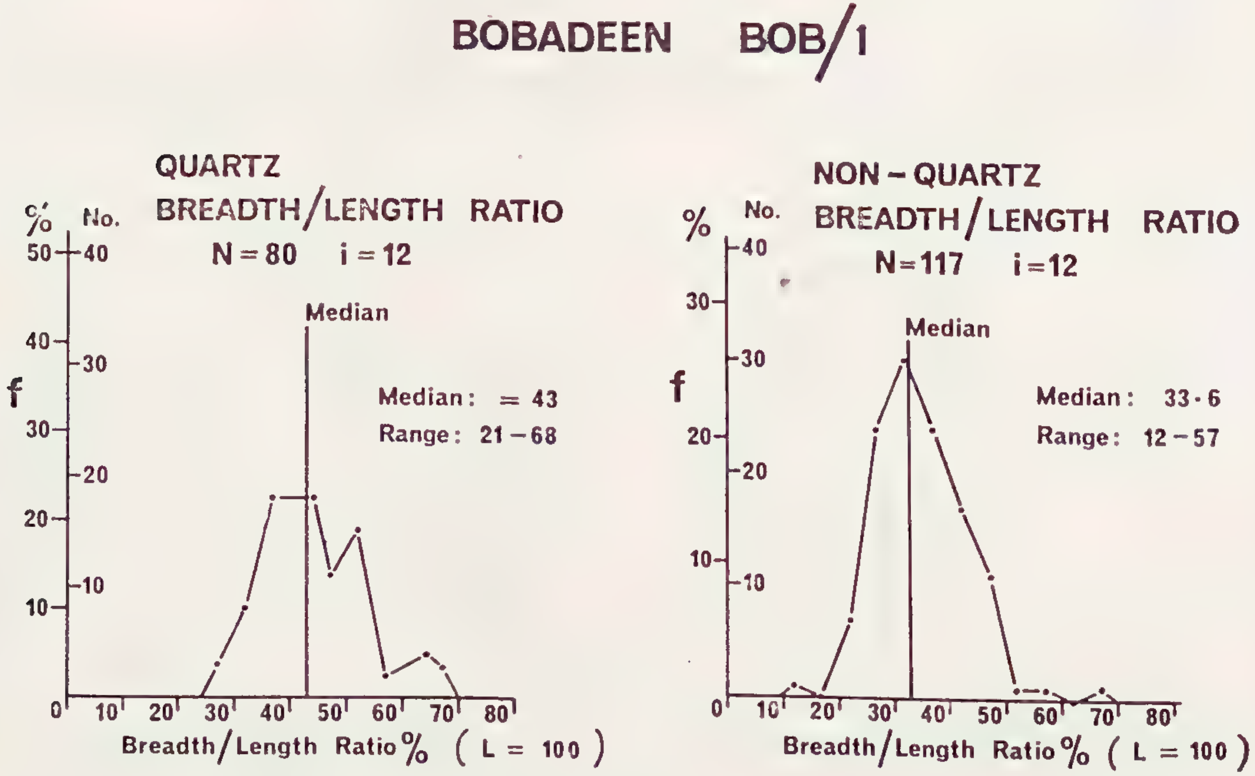
Figures 18–26. Comparative Frequency Polygons: Bondi Points

The bimodalism of the SH/1 length curve may be echoed also in the SH/1 curves for breadth and thickness (figs 12 and 15), which would seem to argue that two particular sizes of Bondi were particularly favoured. For BOB/1 all three curves are consistently close to normal, and this endorses the subjective view gained during excavation that the craftsmanship of the Bobadeen toolmakers was of a higher and more consistent order than that at the two Hunter sites, particularly in view of the more varied materials used at Bobadeen.

No significant difference in weight is shown by figs 18–20, but the polygons for cutting angle (figs 21–23) show marked variations, though bimodalism is present in each case. The more obtuse angle apparently favoured at M/1 has already been shown in the table of means (Table 10), but it appears in addition that cutting angles of approximately 30° and 40° predominated at each of the three sites. Possibly this is some mechanical limitation imposed by the natural fracture lines of the material used. If this is so, then the tendency in question would be that of chert, which predominates in the material used at each site. It would probably not apply to quartz, but this is only significant in the case of BOB/1; most likely the curve for cutting angle for specimens from that site is dominated by the slightly greater occurrence of chert Bondis (see Table 9).

The breadth/length polygons again reflect the preponderance of short stubby blades at BOB/1 and the near perfect bell-curve endorses the consistency of the working at this site. The bimodalism of the M/1 curve may be an exaggeration imposed by the smallness of the sample.

The two final polygons (figs 27–28) compare the breadth/length ratios for quartz and non-quartz Bondis from BOB/1. The latter is close to a normal distribution, whereas the quartz polygon clearly reflects the short chunky form imposed by the material. If these curves are compared with the breadth/length curve for all Bondis from BOB/1 (fig. 26) it will be seen that the non-quartz curve approximates quite closely, whereas the quartz curve shows a marked preponderance of blades in the



Figures 27, 28. Comparative Frequency Polygons: Bondi Points

35–55 range. It is undoubtedly far more difficult, if not impossible, to make a long fine blade from quartz than it is from chert or even quartzite. The possible reasons for the use of such a recalcitrant material as quartz, in preference to excellent cherts, are discussed in the next section.

Finally, it is possible to work out from the Carbon-14 dates obtained for each of the three sites the approximate rate of deposition of material and to provide a comparative table. Naturally these figures do not allow for possible erosion, nor for variations in the compaction of the deposits, but they may serve as a rough guide to the probable time-span of the various levels and horizons.

Table 12. Estimated Rates of Deposition

Sandy Hollow (SH/1).—18 inches in 770 years. Average: 1 inch in 42 years.

Milbrodale (M/1).—6 inches in 780 years. Average: 1 inch in 130 years.

Bobadeen (BOB/1).—24 inches in 7,020 years. Average: 1 inch in 292 years.

In general these figures reflect fairly closely the differential degree of compaction of the deposits at the three sites. S H/1, in the horizons bracketed by its carbon dates, contained a light humus, merging into fairly loose yellow sand at about 30 inches depth. M/1, apart from the first few inches of humus, contained a fairly compacted yellow grit, probably derived mainly from the sandstone of the shelter itself. BOB/1 was stratified into alternating horizons of humus and very hard compacted grit in its top 18 inches, and below that merged into very compacted yellow grit.

SUMMARY AND COMMENT

If the approximate rates of build-up of deposits, as given in Table 12 at the end of the previous section, are extrapolated to include the levels not carbon dated, we can arrive at a tentative time-sequence for each of the three main excavation sites. For example, at SH/1 the earliest cultural material occurred in the top of Level 7 in both Square A and Square AA. This is 14 inches lower than the charcoal sample dated to A.D. 650. With an average build-up of 1 inch in 42 years, this would give a starting date of approximately A.D. 70. However, any attempt to apply a similar method to the end of occupation would be unlikely to have any validity, because of the mixing and movement of the top few inches of deposit during the 150 or so years since the start of European settlement and also because the removal of tree cover would materially alter the rates of deposition and erosion. The following table compares the carbon dating from the three sites and gives a tentative estimation of the time sequence for levels not so dated.

Table 13. Comparison of Carbon Dates and Estimated Dates

Depth (inches)	Sandy Hollow SH/1	Milbrodale M/1	Bobadeen BOB/1
4–6	**A.D. 1420 (ANU-125)**	**A.D. 1320 (ANU-121)**	**A.D. 1220 (ANU-123)**
12	A.D. 1150	**A.D. 540 (ANU-122)**	530 B.C.
18	A.D. 900	240 B.C.	2280 B.C.
24	**A.D. 650 (ANU-12)**		4030 B.C.
30	A.D. 400		**5800 B.C. (ANU-124)**
36	A.D. 150		7550 B.C.
38	A.D. 70		

Note: Carbon-14 dates are in bold type.

It will be noticed that the tentative time sequences for the two upper Hunter sites (SH/1 and M/1) are quite consistent, whereas at BOB/1, only 50 miles away at the source of the Goulburn River, occupation appears to have begun some 7,000 years earlier. On the other hand, the Bobadeen date is quite plausible in relation to the carbon dates for the sites in the Capertee Valley obtained by McCarthy and Tindale. McCarthy dated his Capertee Site 3 to 5400 B.C., while Tindale obtained a date of about 9500 B.C. from Noola Cave in the same valley. However, the Capertee results pose another problem. McCarthy's Bondaian at Capertee had a time span from approximately 1700 B.C. to 900 B.C. and his earlier date marks the start of the Capertian, while Tindale's date is apparently associated with uniface pebble material. Nothing resembling a Capertian assemblage was found at Bobadeen and, assuming ANU-124 and 287 are correct, we certainly have Bondi points dated to 3200 B.C. and possibly to 5800 B.C. at a site only some 50 miles from the Capertee Valley. Pending receipt of further C14 estimations from BOB/1, there is no point in speculating on these anomalies.

Turning to the upper Hunter situation, on present evidence it would seem that occupation began there comparatively late, at about the start of the Christian era. It is interesting to compare McBryde's results from the North Coast region. Her earliest date from east of the Dividing Range was obtained from Seelands shelter, on the Clarence River, and is of the order of 5000 B.C., representing a large flake and uniface pebble industry, while the Bondaian from Seelands was dated from approximately 2000 B.C. to A.D. 1500. Until recently the earliest date from the coastal side of the Dividing Range was Megaw's 5500 B.C. from Curracurang, a rock shelter site just south of Sydney. This is associated with an industry possibly equating with McCarthy's Capertian. The Bondaian time sequence at Curracurang appears to be approximately 400 B.C. to A.D. 1100. Late in 1968, however, a date of the order of 20,000 B.P. was obtained by R. Lampert from a rock shelter at Lake Burrill on the south coast of New South Wales. This date also appears to be associated with a Capertian type of material.

Regarding the termination of occupation in the upper Hunter sites, on present evidence there is no reason to suppose that they were not in use up to the beginning of European settlement in the valley. If this is so, then it would appear that the Bondi point also was still in use, since both SH/1 and M/1 contained numbers of Bondi points in the top levels. SH/1, in fact, had several actually lying on the surface inside the shelter. The situation at BOB/1 would seem to be similar, since Bondi points were prolific in the top levels. Ground-edged axes and eloueras were also found in the top levels at M/1 and BOB/1, but neither the material nor the dating can be said to indicate any evidence of a change to Eloueran in the sequence.

Turning to problems specifically relating to the Bondi point as a tool, the presence of work-use and/or retouch on the chords of a significant proportion of Bondis from all three sites (see Table 8) supports the view that the Bondi may have been a general-purpose hafted cutting and boring implement, rather than exclusively a spear barb and point, as maintained by McCarthy and others. In this connection, it should be mentioned that McCarthy and Davidson (1943) found work-use on 72 out of 524 Bondi points collected from the Singleton terraces, while McCarthy recorded work-use on 13 out of 33 from Bathurst, 16 out of 186 at Lapstone Creek, and 275 out of 2,340 from the South Coast of New South Wales. There were also definite traces of gum along the backs of four Bondis and possibly also on two others (see plate 12). Another reason for doubting that the Bondi was intended specifically as a spear barb or point is that the bone point which supposedly replaced it in no way resembles a Bondi. The most common form, the double point sometimes called a "muduk", is usually ground with flattened sides, so that in cross-section it is oval. There is no attempt to make one margin sharp and the other blunt. The muduk was usually bound into the spear head with sinew and firmly fixed with gum. In the case of the Bondi, if used in this way the sharp chord would have pressed against the sinews and would have tended to cut them. The oval form of the muduk, on the other hand, fits snugly into the slot in the spear head and does not abrade the binding.

A further problem was that nearly half of the Bondis from Bobadeen were made of quartz, a comparatively intractable material, although excellent cherts are available; most of these quartz Bondis are stubby little blades, less than 2 centimetres long. One can only assume that quartz, in spite of the difficulty of flaking it satisfactorily, was favoured for its acute cutting properties. If used as cutting implements, such microlithic quartz blades must have been hafted. Although quartz waste was encountered at both SH/1 and M/1, no quartz implements were found at Sandy Hollow and only two at Milbrodale—a Bondi point and an unbacked point; this is not a sufficient sample to draw any conclusions.

Evidence of trade or contact between the upper Hunter people and the tribes inland is not specifically present in any of the excavated material, unless the presence of quartz-working in the upper Hunter sites may be taken as evidence of trade; certainly no signs of outcrops of quartz were found in the area of either of the excavations. The general similarity of the industries at the three sites would seem to argue either that there was considerable contact or that the upper Hunter people were originally a sub-group of the inland people. However, the apparent late occupation of the upper Hunter region and the hostile relationship between the Geawegal and Wonarua, on the one hand, and the inland Gamilaroi people on the other, would seem to argue against the latter hypothesis. It is possible that the Hunter system may have been occupied from the coast. This could be quite consistent with the geography of the region, since the Great Dividing Range would have constituted a formidable barrier in most places, whereas to a people skilled in navigating sheltered inland waters, movement up and down the coastal plain and up the river valleys would have presented no problem.

The questions posed by the situation along the 200-foot terrace at Singleton are not yet satisfactorily answered. However, there can be no doubt that the material collected by McCarthy and Davidson and that excavated and collected by Australian Museum parties in 1966 contains the same microlithic and backed blade complex as that excavated at SH/1 and M/1. One can, therefore, presume that the terrace was occupied during approximately the same period as the rock shelter sites, i.e., from about the beginning of the Christian era until European settlement. However, if the assumption that the material in the terrace is condensed and mixed is correct, then the other component—the somewhat crude flake implements of pink quartzite—may represent the remains of an earlier occupation.

No valid conclusions regarding the Hunter Valley industries can be reached until the survey has been extended into the estuaries and lagoons of the Newcastle-Port Stephens area. It may be that occupation sites of greater antiquity will be found there, in which case, granted that the industries are similar, it would be reasonable to assume that the people spread up the valleys from the sea coast.

In any case, the various hypotheses put forward here are purely tentative at this mid-point in the survey.

APPENDIX

Skeleton Discovered by Schoolboys at the SH/1 Site

Following publication in the *Newcastle Herald* in July 1966 of an article describing the Australian Museum's work in the upper Hunter Valley, the text was reproduced verbatim by most of the local newspapers in the valley. As a result, there was great excitement, particularly at Sandy Hollow, where school children ranged the countryside, searching for caves and Aboriginal tools. One of these parties apparently located the SH/1 shelter and, while scratching around in the loose surface dust within the east entrance, uncovered a skeleton, only a few inches down.

The Postmaster at Sandy Hollow, Mr Horner, whose nephew was a member of this party, immediately phoned the Museum and subsequently sent a fairly detailed account. As it was impossible to investigate at the time, he was asked to keep the skeleton until it could be picked up; he was also requested to plot the position of the find on a sketch plan and record as much information as possible while it was still fresh in the boys' minds.

As it turned out, it was not possible to follow this up until May 1967, by which time Mr Horner had been transferred elsewhere. However, he had deposited the bones and a sketch plan with relatives and these were handed over, with the additional information that the skull had been jammed beneath a rock ledge so that the boys could not extricate it. A small party returned to the SH/1 shelter and excavated a trench at right angles to the original excavation, at the point indicated on Mr Horner's plan. At a depth of about 6 inches we found some fragments of what appeared to be a human humerus, but there were no further traces down to a depth of 2 feet, nor was there any sign of a skull. The area appeared remarkably undisturbed and contained stone artefacts similar to those previously excavated, but nearly a year had elapsed since the boys had interfered with the site. We could only assume that someone had come subsequently and removed the skull as a souvenir.

The skeletal remains handed over were in very good condition and carefully wrapped in cotton wool. They included a mandible, with some teeth intact. The stratigraphic position of the burial seemed to indicate that it was comparatively recent and probably unrelated to the artefactal deposits; this inference was reinforced by Alan Thorne, of the Department of Anatomy, University of Sydney, who, on inspection of the remains, estimated that they were those of an Aboriginal woman of about 60, and of recent date. Professor N. W. G. Macintosh later confirmed this opinion.

This may well be a post-European burial, intruding into an older deposit and similar in age to the fragmentary skeleton excavated at Milbrodale.

ACKNOWLEDGEMENTS

Without the support of Dr J. W. Evans, Director of the Australian Museum in 1966, this project could not even have started, and this support was continued enthusiastically by his successor, Dr F. H. Talbot. After the completion of the SH/1 excavations, a series of small research grants from the Australian Institute of Aboriginal Studies enabled the work to continue without interruption and my grateful thanks are due to the Institute and its Principal, Mr F. D. McCarthy, who has taken a personal interest in the project from its inception.

Particular thanks are due to members of the various field parties, both from within the Museum and from outside, who have worked so willingly and helped to make the somewhat slow and often wearisome business of excavation both entertaining and enjoyable. Chief among these helpers have been F. J. Beeman, who was then the Museum's Exhibitions Officer, and members of his department, David Rae, Brian Bertram, Helen Ashton, Lori Zirkzee, Kingsley Gregg, and Peter Fluke. Others who have assisted at various times include Dr John Yaldwyn, Beverley Ingram, and Vaughan Edwards. Dr S. M. Bard, of Hong Kong, devoted the best part of his sabbatical leave in 1967 to excavating and sorting material as a more than willing volunteer. Charles Turner, of the Museum's Photographic Department, and Elvie Brown, Helen Ashton, and Beverley Crewe, of the Art Department, gave expert assistance with the illustrations.

Richard Wright, of the University of Sydney, has always been ready with advice and helpful suggestions, Dr D. Branagan and Lloyd Hamilton gave much useful geological information, Professor N. W. G. Macintosh and Alan Thorne reported on skeletal material excavated, and many residents of the Hunter Valley gave willing co-operation to the various field parties.

Finally, my special gratitude must go to my assistant, Kathleen Pope, who helped with every stage of the survey and never failed to do everything possible to free me from routine chores so that I could give all my attention to planning and interpretation, and to my wife, who worked on several of the "digs" and cheerfully tolerated all the often inconvenient comings and goings.

REFERENCES

Aust. Inst. Ab. Studies (1966). Recent Australian Carbon Dates. *A.I.A.S. Newsletter*, 2 (3): 20–26.

Barrallier, Francis (1802). Letter to C. F. Greville. In Banks Papers: Brabourne Collection, 4: 78–83.

Brayshaw, Helen C. (1966). Some Aspects of the Material Culture of the Aborigines of the Hunter Valley at the time of the First Settlement in the Area. Unpublished B.A. Thesis, University of New England.

Breton, W. H. (1833). Excursions in New South Wales, Western Australia, and Van Diemen's Land during the years 1830, 1831, 1832, and 1833.

"Brisbane Water" [pseudonym] (1877). "Mogos". *Maitland Mercury*, 23rd October, 1877.

Browne, W. R. (1924). Notes on the Physiography and Geology of the Upper Hunter River. In *J. & P. Roy. Soc. N.S.W.*, 58: 128–144.

Dalhunty, J. A. (1938). Stratigraphy and Physiography of the Goulburn River District, N.S.W. In *Proc. R. Soc. N.S.W.*, 71: 297–317.

Darling, Governor Sir R. (1826). Despatches to Earl Bathurst. In Governors' Despatches, 7: 387–396. Mitchell Library.

Darling, Governor Sir R. (1827). Despatches to Earl Bathurst. In Governors' Despatches, 9: 754–760. Mitchell Library.

Dawson, R. (1830). The Present State of Australia.

Fawcett, J. W. (1898). Notes on the Customs and Dialect of the Wonnahruah Tribe. *Science of Man*, n.s., 1 (7): 152–154. 1 (8): 180–181.

Galloway, R. W. (1967). Pre-basalt, Sub-basalt and Post-basalt Surfaces of the Hunter Valley, N.S.W. In Landform Studies from Australia and New Guinea: 293–314.

Grant, H. (1896). Natives of the Hunter River (1801). In Hist. Recs N.S.W., 1896: 406–407, 417.

Green, W. C. (1959). "Gundy". In Scone and Upper Hunter Hist. Soc., 1: 113–121.

Howe, John (1819). Field Book of His Journey from Windsor to the Hunter Valley in 1819 and Related Correspondence. Mss, Mitchell Library.

Howitt, A. W. (1904). The Native Tribes of South-East Australia.

Lang, Rev. J. D. (1831?). Notes on the Settlement of the Hunter River District, 1815–1829, and its Aborigines. In Papers of Rev. J. D. Lang, 1: 59–65. Mss, Mitchell Library. [Note: these memories are not by Lang himself, but must have been acquired from some original settler.]

McBryde, I. (1965). Radio-carbon Dates for Archaeological Sites in the Clarence Valley, Northern New South Wales. *Oceania* 35 (4): 260–266.

McBryde, I. (1966). Radio-carbon Dates for Northern New South Wales. *Antiquity*, 40 (160): 285–292.

McCarthy, F. D. (1939). Report on an Archaeological Reconnaissance to Wollombi and the Hunter Valley. Typescript, Aust. Mus.

McCarthy, F. D. (1948). The Lapstone Creek Excavation. In *Rec. Aust. Mus.*, 22: 1–34.

McCarthy, F. D. (1964). The Archaeology of the Capertee Valley, N.S.W. In *Rec. Aust. Mus.*, 26: 197–246.

McCarthy, F. D. (1967). Australian Aboriginal Stone Implements. Aust. Mus. publication.

McCarthy, F. D. and F. A. Davidson (1943). The Elouera Industry of Singleton, Hunter River, N.S.W. In *Rec. Aust. Mus.*, 21 (4): 210–230.

McCarthy, F. D., Bramell, Elsie, and H. V. Noone (1946). The Stone Implements of Australia. *Mem. Aust. Mus.*, 9.

Matthews, R. H. (1893). Rock Paintings by the Aborigines in Caves on Bulgar Creek, near Singleton. In *J.Roy. Soc. N.S.W.*, 27: 353–358.

Matthews, R. H. (1904). Ethnological Notes on the Aboriginal Tribes of New South Wales and Victoria. In *J.Roy. Soc. N.S.W.*, 38: 203–380.

Megaw, J. V. S. (1965). Excavations in Royal National Park, N.S.W. *Oceania*, 35 (3): 202–207

Megaw, J. V. S. (1966). Report on Excavations in the South Sydney District, 1964–65. *A.I.A.S Newsletter*, 2 (3): 4–15.

Megaw, J. V. S. (1967). Radiocarbon Dates for Curracurrang Cove, N.S.W. *A.I.A.S. Newsletter*, 2 (5): 34–41.

Miller, R. (1886). The Hunter River: the Wonnarua Tribe and Language. In Curr, E. M. The Australian Race, 3, 1887: 352–357.

Mitchell, T. L. (1839). Three Expeditions into the Interior of Eastern Australia.

Moore, D. R. (1967). Archaeological Field Survey of the Hunter River Valley, N.S.W., by the Australian Museum: a preliminary report. *A.I.A.S. Newsletter*, 2 (5): 34–41.

Moore, D. R. (1969). The Prehistory of the Hunter River Valley. *Aust. Nat. Hist.*, 16 (5): 166–171.

Mountford, C. P. (1963). Australian Aboriginal Skin Rugs. In *Rec. S.A. Mus.*, 14 (3): 525–543.

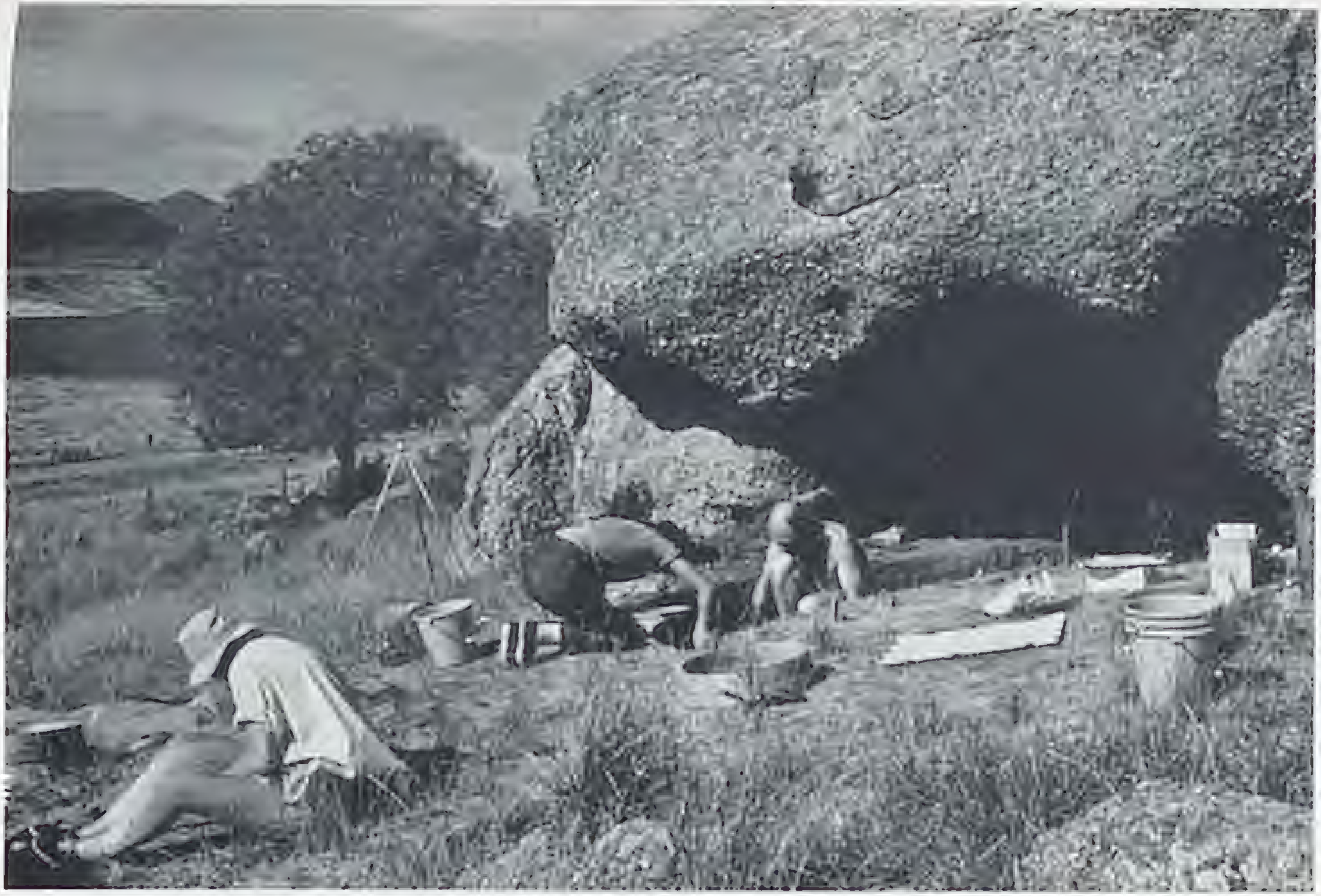
Paterson, William (1801). Journal of Hunter River Expedition. *Hist. Rec. Aust.*, 1 (3): 174–180.

Raggatt, H. G. (1938). Evolution of the Permo-Triassic Basin of East-Central New South Wales. Unpub. D.Sc. Thesis, University of Sydney.

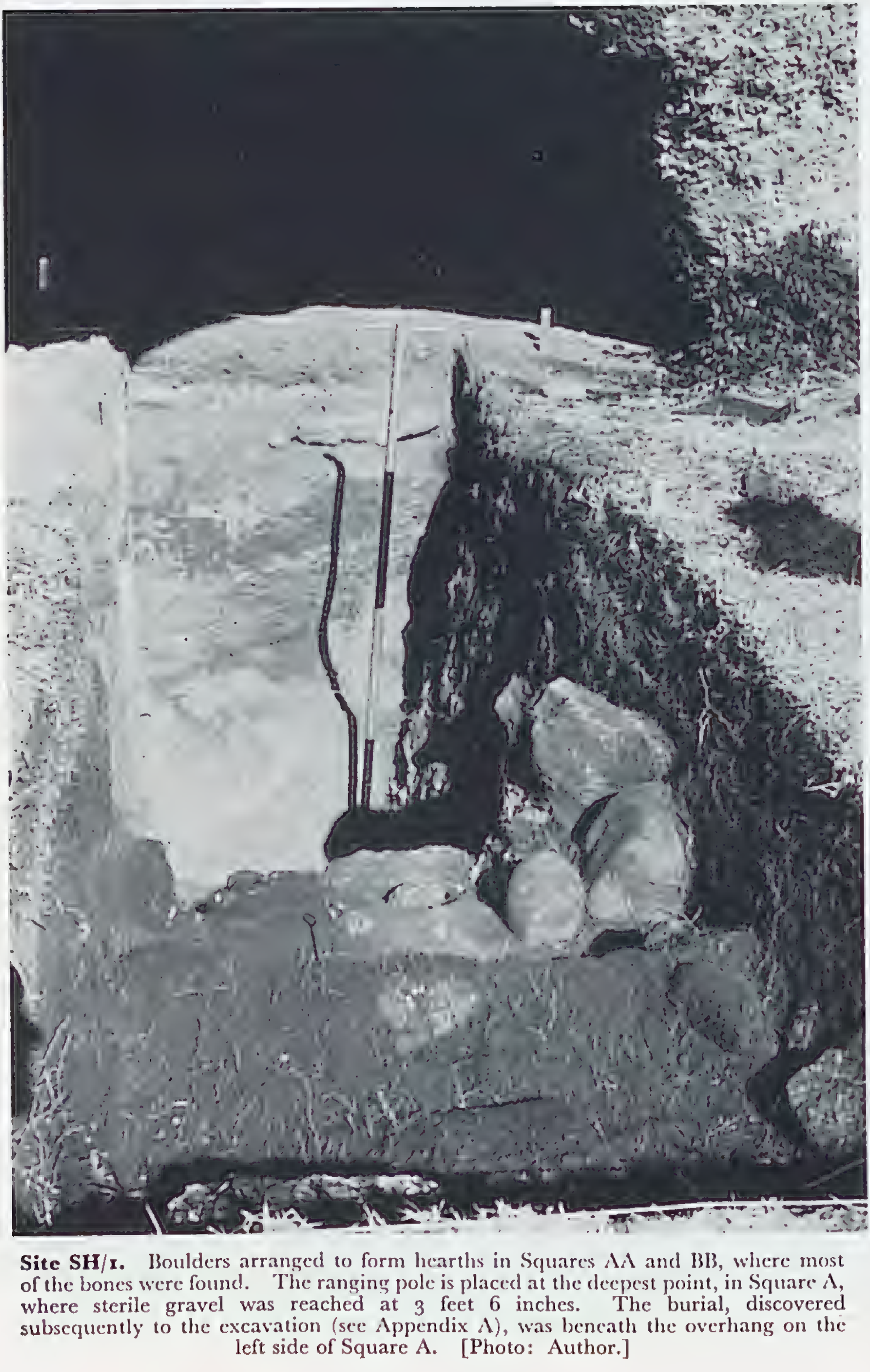
Tindale, N. B. (1961). Archaeological Excavation of Noola Rock Shelter: a preliminary report. In *Rec. S.A. Mus.*, 14: 193–196.

White, J. P. (1968). Fabricators, Outils Écaillés, or Scaler Cores? *Mankind*, 6 (12): 658–666.

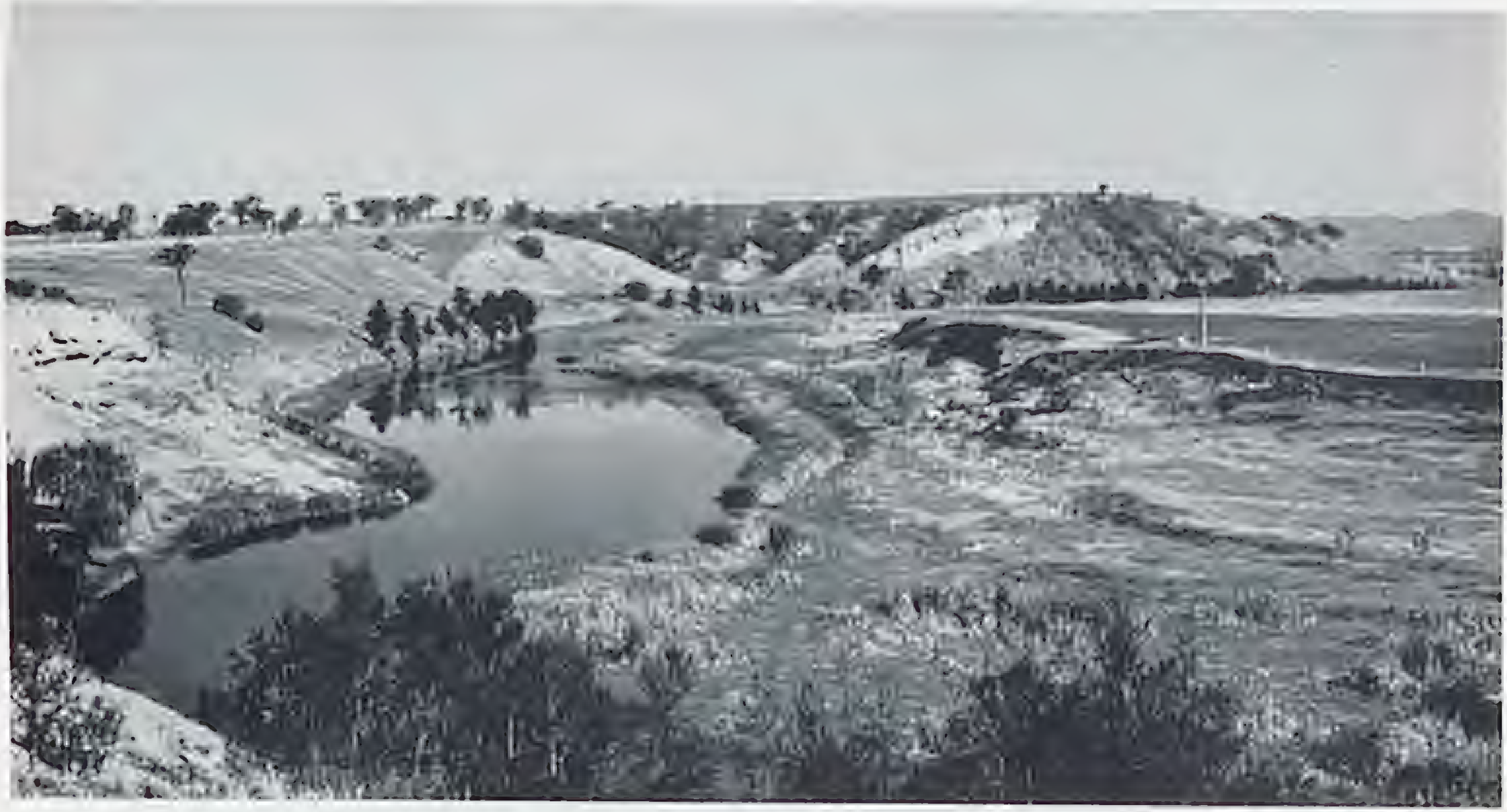
V. C. N. Blight, Government Printer, New South Wales—1970



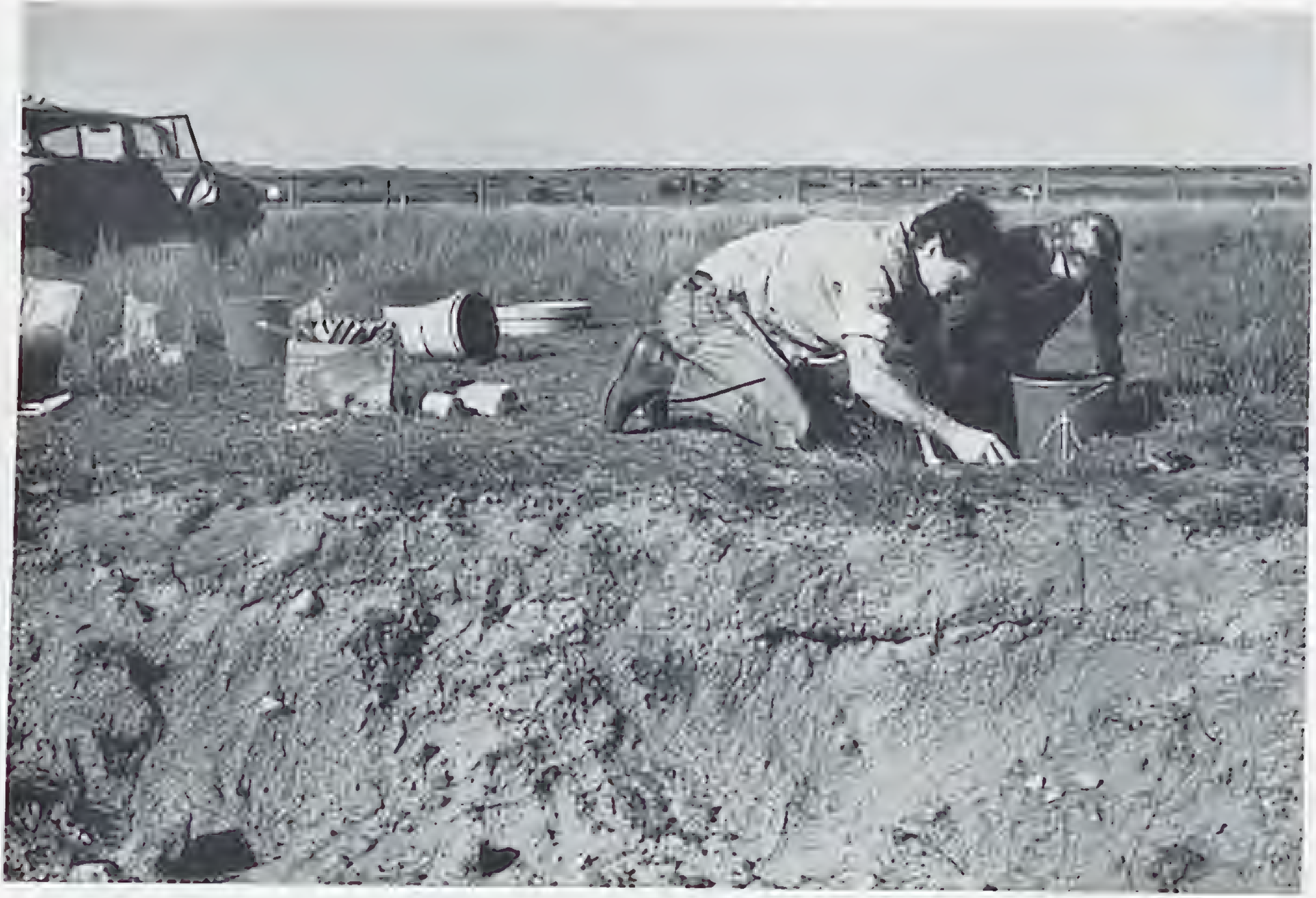
Site SH/1. The east entrance of the Sandy Hollow shelter, showing the alignment of the squares, in a continuous trench along an east-west datum line. The banks of the Goulburn River can be seen (far left), about 900 yards distant. [Photo: G. Moore.]



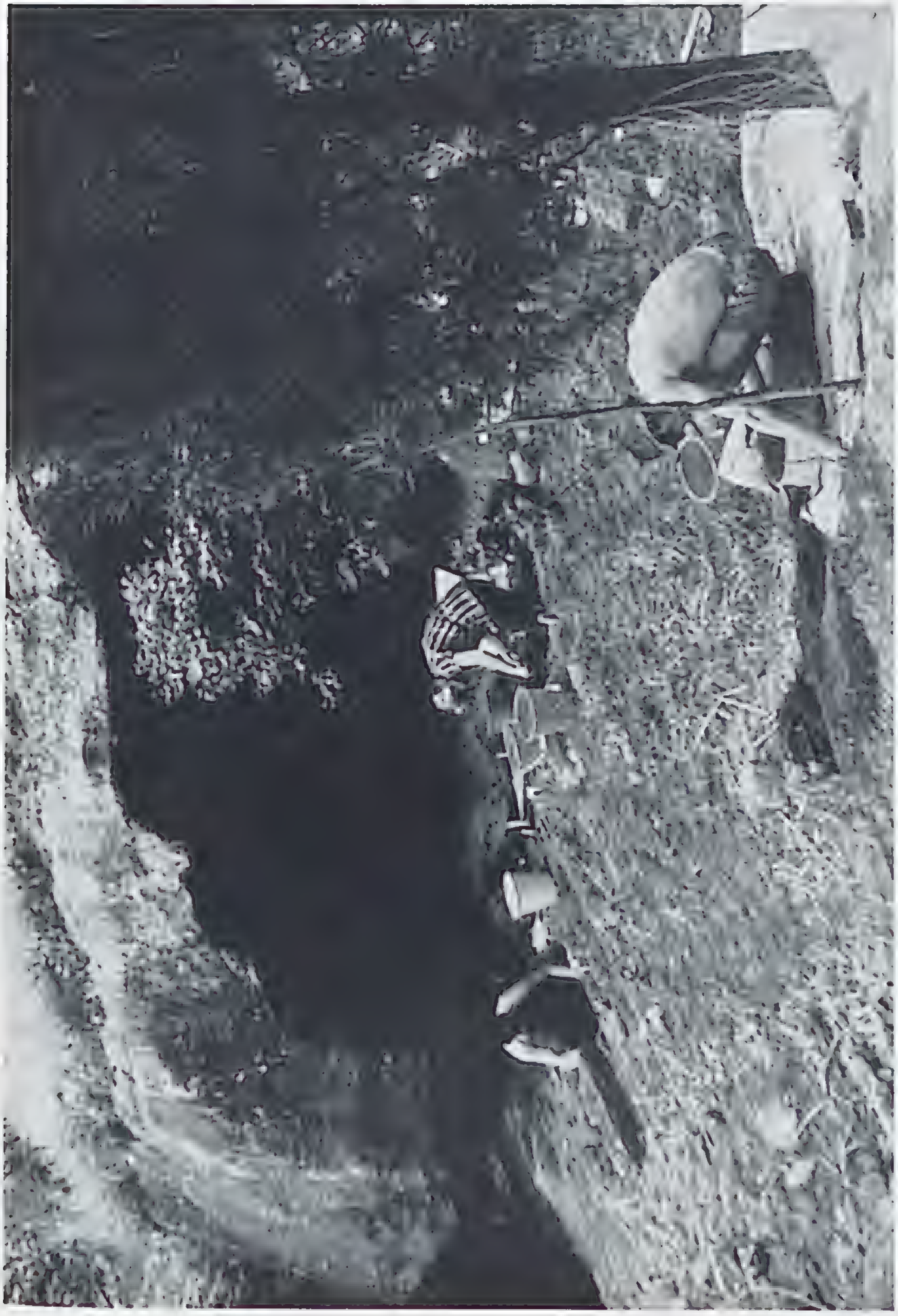
Site SH/1. Boulders arranged to form hearths in Squares AA and BB, where most of the bones were found. The ranging pole is placed at the deepest point, in Square A, where sterile gravel was reached at 3 feet 6 inches. The burial, discovered subsequently to the excavation (see Appendix A), was beneath the overhang on the left side of Square A. [Photo: Author.]



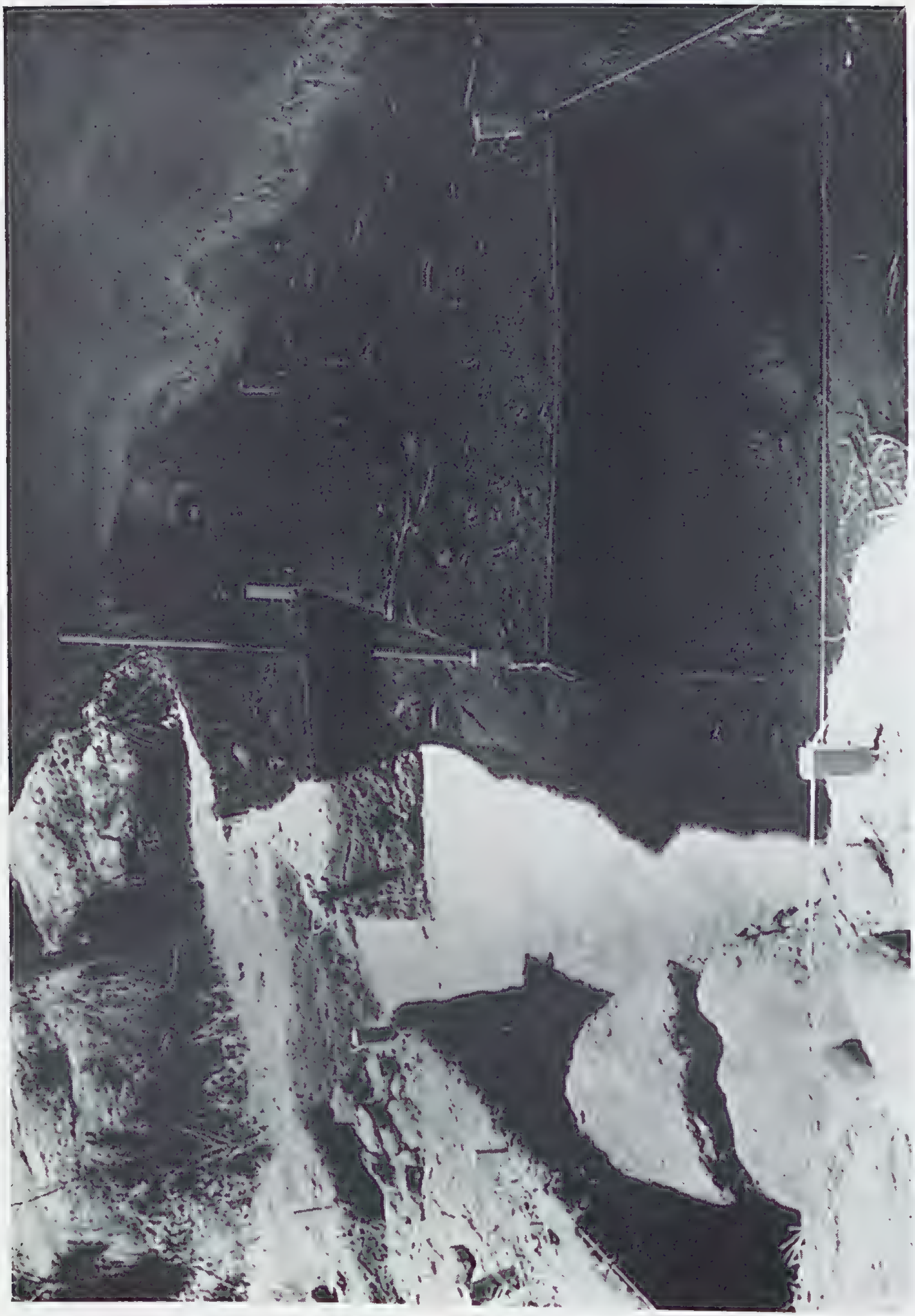
Site S/1. The Gowrie terrace, northwest of Singleton, with the Hunter River 60 feet to 100 feet below. The trial trenches at S/1 were dug across the terrace at the erosion point at top left. [Photo: Author.]



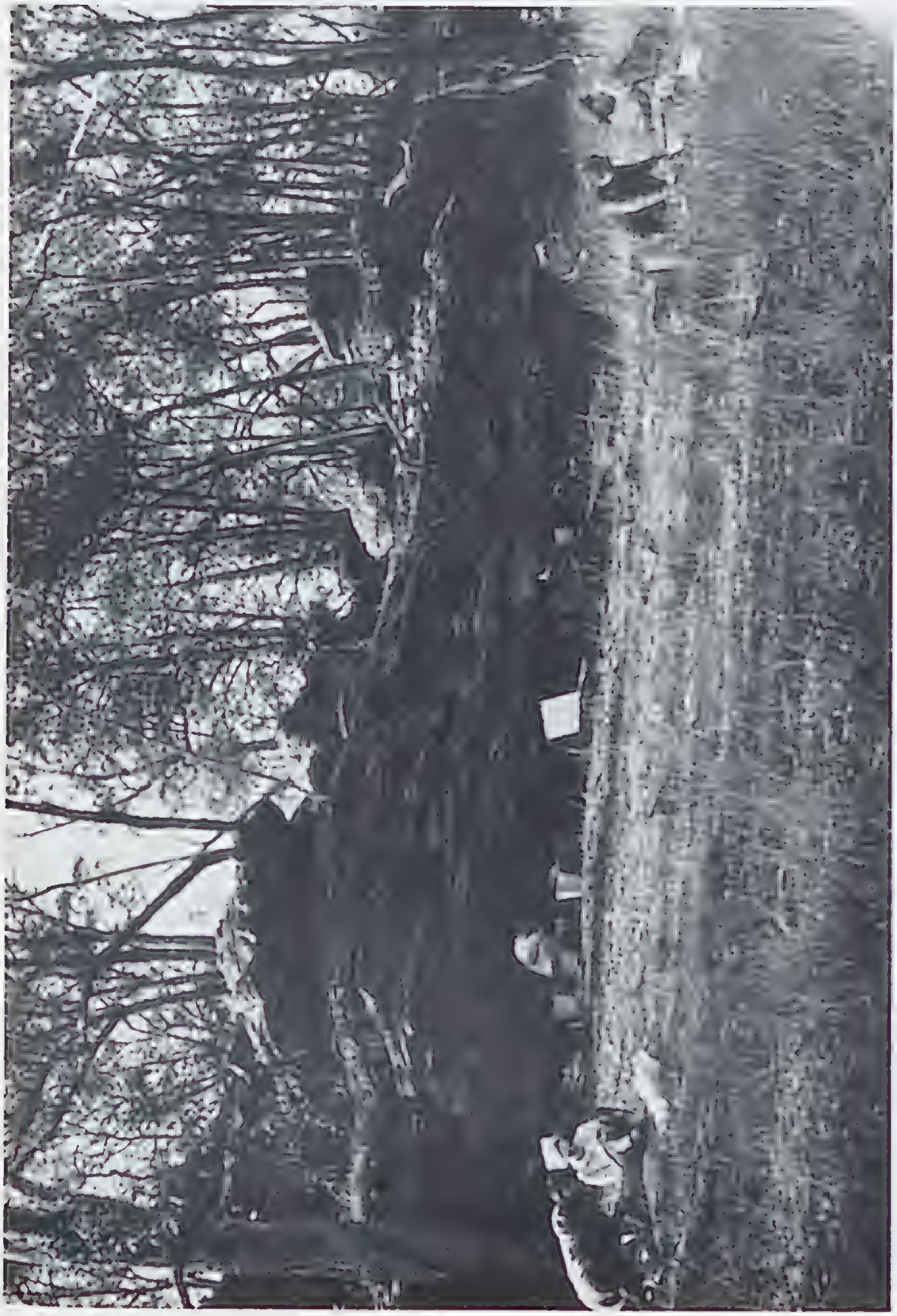
Site S/1. The commencement of the trial trenches. In the foreground artefacts can be seen sticking in the underlying clay. The dark longitudinal crack represents the base of the overlying topsoil from which the artefacts erode. [Photo: Author.]



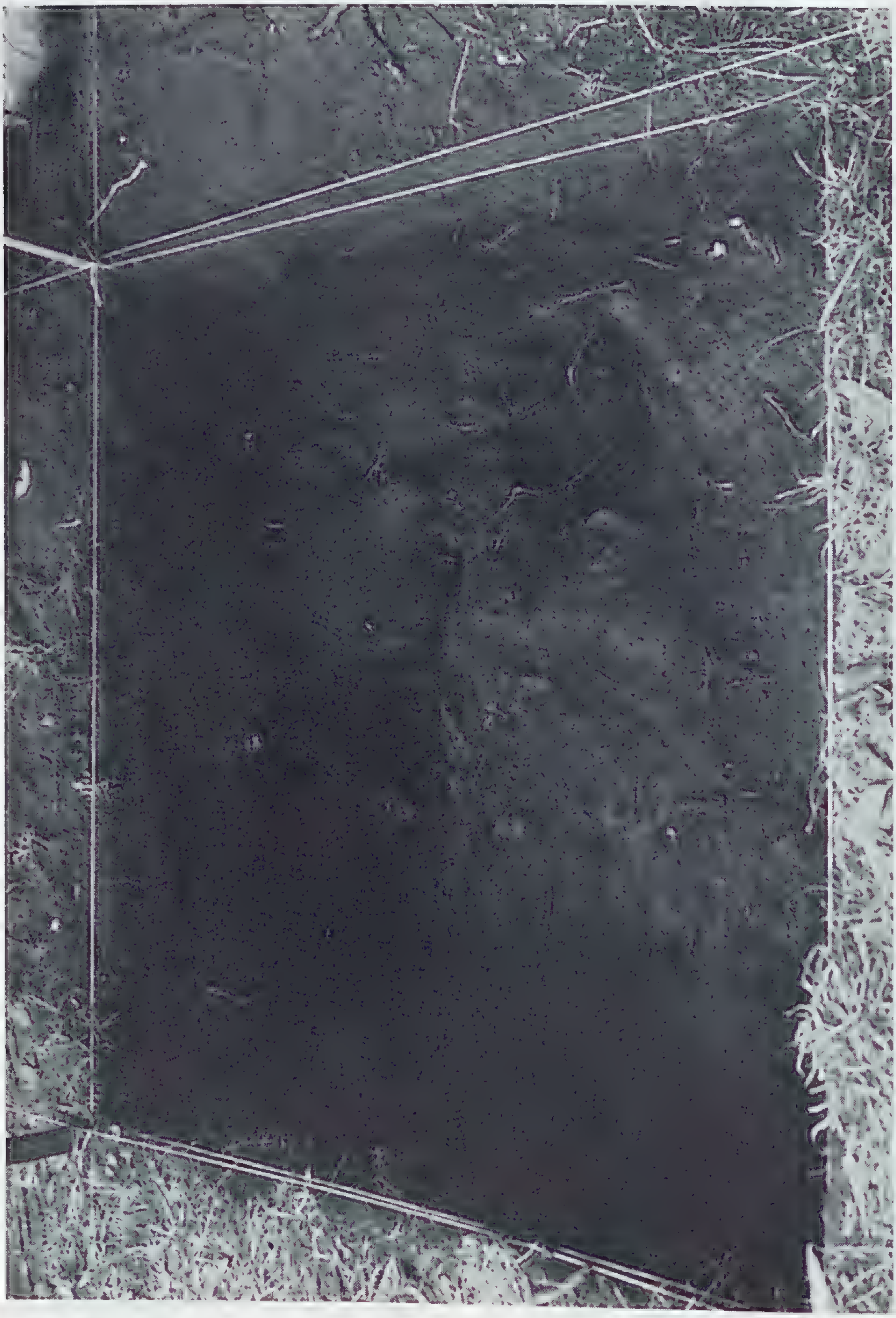
Site M/1. A general view of the main shelter at Milbrodale with the excavation in progress. This shelter stands about 50 feet above the valley floor, up a steep slope. Immediately above it is a second shelter. [Photo: Author.]



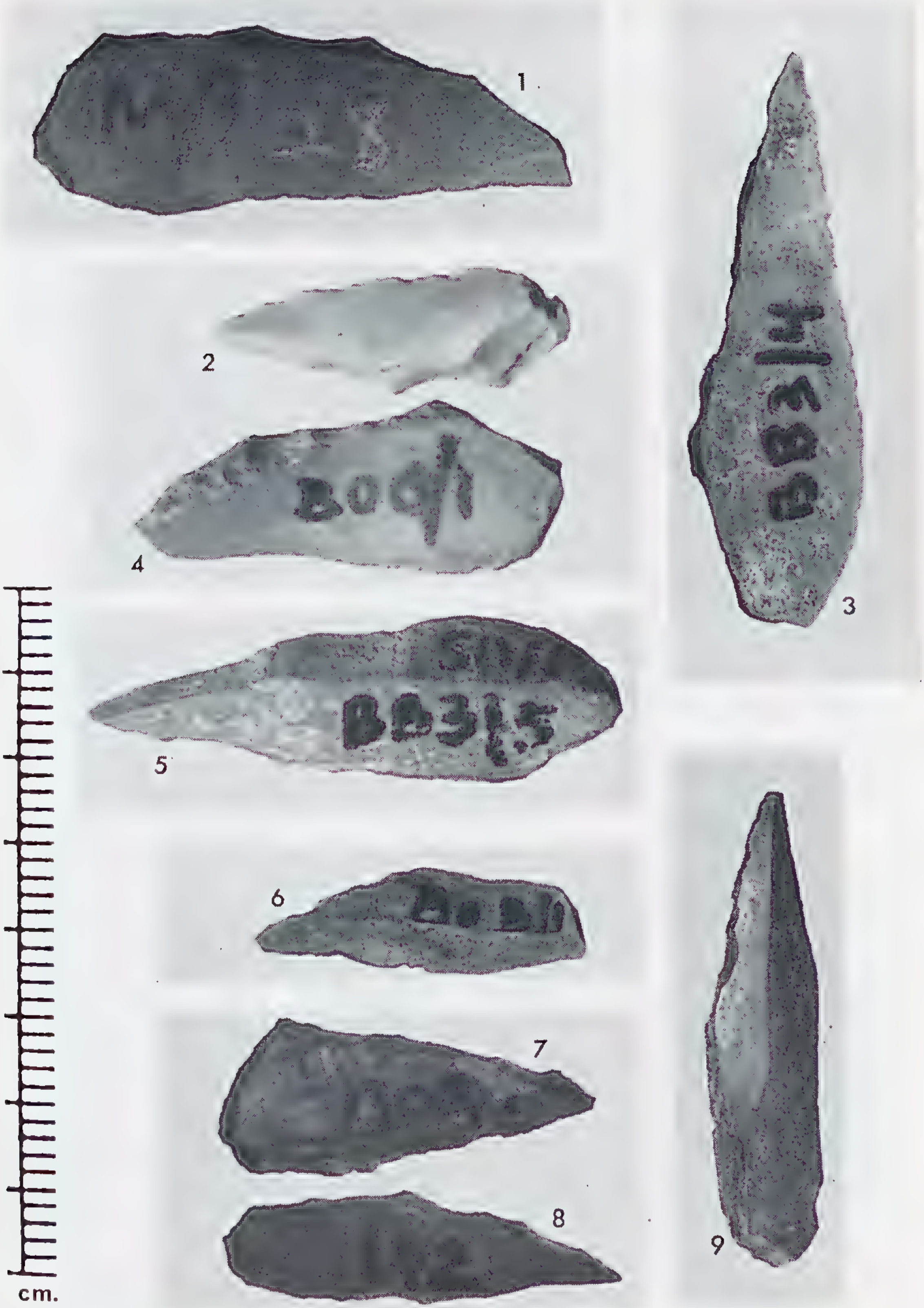
Site M/1. The completed excavation. This was a shallow deposit and called for extensive trenching in order to obtain a satisfactory sample. [Photo: Author.]



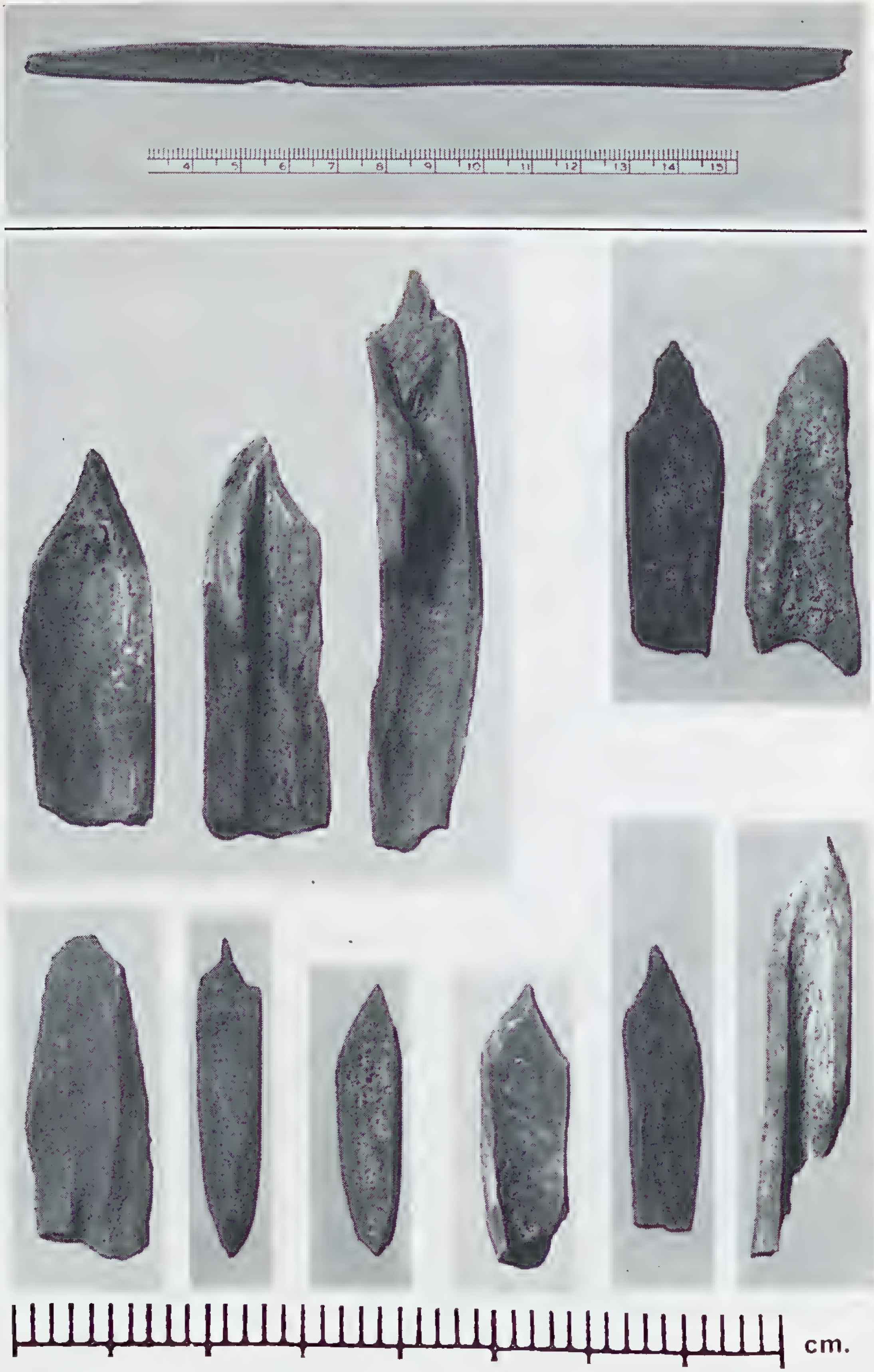
Site BOB/1. The small but prolific shelter at Bobadeen, with two digging and two sieving teams at work. (One of the teams is obscured from sight in the background.) The conglomerate sandstone slabs above the shelter contain quartz nodules. [Photo: Author.]



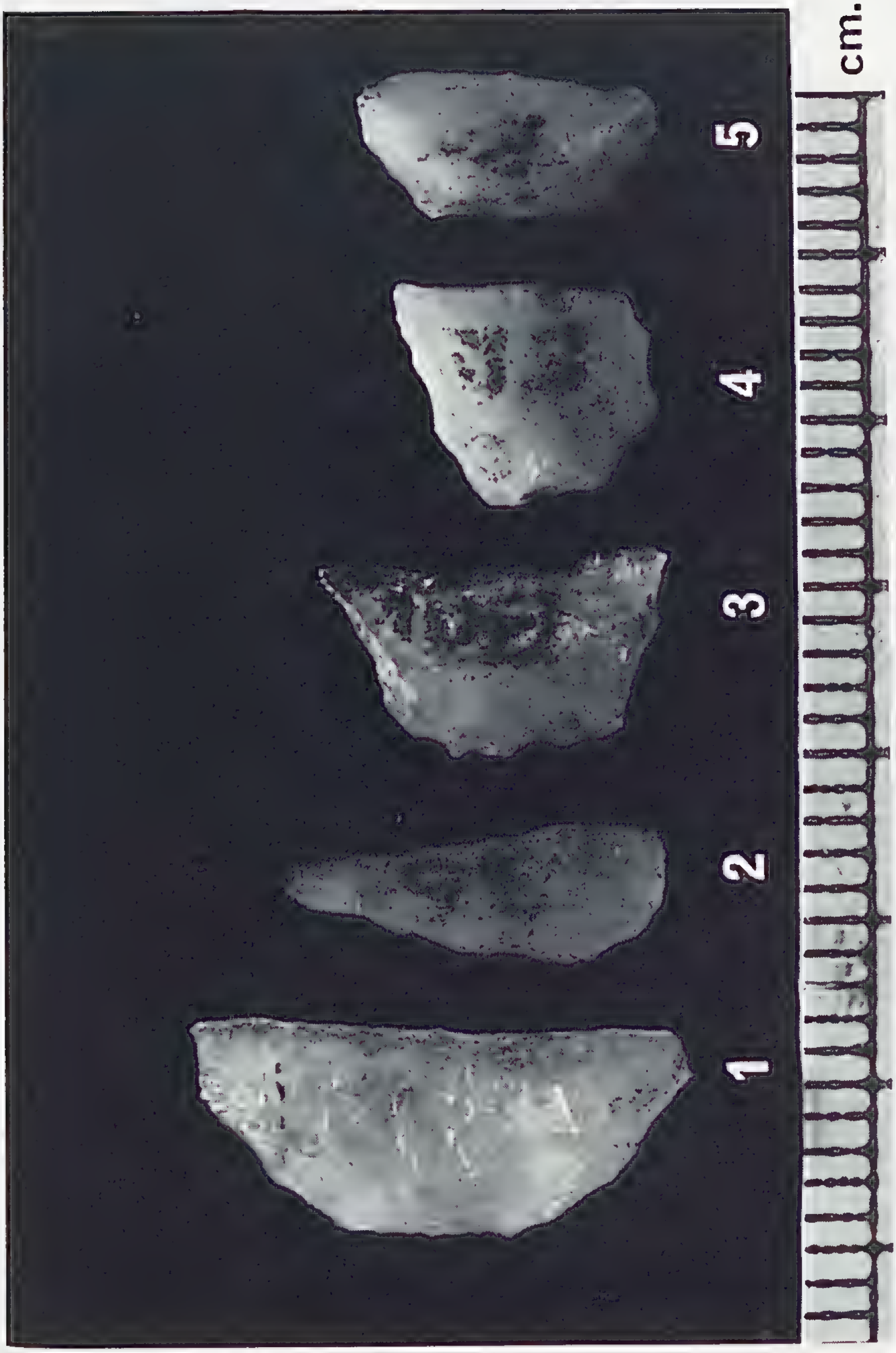
Site BOB/1. The first compacted layer in Square H. The breaks in the surface were caused by tree roots, which had travelled preferentially along the hard surface. These layers, and the humus between them, were especially prolific in artefacts. [Photo: Author.]



Bondi points. (x2½) (1) From M/1, showing work-use. (2) The solitary quartz Bondi from M/1, with marked retouch on the chord. (3, 5) From SH/1 and (4, 6, 7, 8) from BOB/1, all showing work-use and/or retouch. (9) From SH/1, with gum on back and butt. [Photo: C. V. Turner.]



Bone Implements. Burin-like bone points ($\times 2\frac{1}{2}$) from BOB/1. Some of the specimens appear to show work-use. The long implement ($\times\frac{2}{3}$) is a bone spatula, showing both grinding and work-use at the tip and cuts on the left margin. The purpose for which these implements were employed remains a matter for speculation. [Photo: C. V. Turner.]



Quartz Microliths (X4). These are all from BOB/1 and demonstrate the remarkable precision of the quartz-working there. The larger segment (1) is less than 1.5 cm long and has a razor-like cutting edge. The smallest Bondi point (2) is 1.2 cm long. The trapezoids (3, 4) and the small segment (5) are less than one cm long. [Photo: C. V. Turner.]

The Genus *Chlorinoides* (Crustacea, Brachyura, Majidae). 2. *Chlorinoides goldsboroughi* Rathbun from Eastern Australia, *C. tenuirostris* Haswell and a New Species from Western Australia

By D. J. G. Griffin

Australian Museum, Sydney

Figures 1–4

Manuscript received 1st May, 1969

ABSTRACT

Chlorinoides goldsboroughi Rathbun, previously known from Hawaii, is recorded formally for the first time from eastern Australia near Sydney in 70–125 fms. A new species of the genus, superficially similar to *C. golsboroughi*, is recorded from off Western Australia between Geraldton and Rottnest Island near Perth in 62–103 fms. The known geographic range of *C. tenuirostris* is extended from northeastern Australia to Western Australia near Pt Cloates. *C. goldsboroughi* and the new species are described and figured.

INTRODUCTION

The Indo-west Pacific spider crabs of the genus *Chlorinoides* Haswell were reviewed in detail by Griffin (1966a), a key to the species was provided, and the type species, *C. tenuirostris* Haswell, was redescribed and figured. A key to the Australian and New Zealand species was provided by Griffin (1966b) and to the Australian species only by Griffin (1966c). Sakai (1965) has illustrated most of the Japanese species and Serene (pers. comm.) has recently studied some others.

From 1961 through 1965 the Australian CSIRO Division of Fisheries and Oceanography carried out surveys off New South Wales on benthic invertebrates (led by Dr R. J. MacIntyre) and, in co-operation with the Western Australian Department of Fisheries and Fauna, off Western Australia on the Western Crayfish (led by Dr R. G. Chittleborough). In Western Australia Drs R. W. George and B. R. Wilson, of the Western Australian Museum, have also carried out investigations into the benthic invertebrate fauna. The results of these surveys have included the finding of *Chlorinoides goldsboroughi* Rathbun, previously known only from Hawaii (Rathbun 1906), off New South Wales, and of a new species superficially similar to this off Western Australia. In addition, *C. tenuirostris*, formerly known in Australia from northern Queensland, has also been found off Western Australia.

In this paper *C. goldsboroughi* is redescribed, the new species is described, and further notes are given on *C. tenuirostris*. Terminology follows that used by Griffin (1966a). The system of measurements is as explained previously (Griffin, 1966b) and the measurements were made to the nearest 0.1 mm with dial calipers; unless otherwise stated, dimensions given are carapace length (including rostrum). Drawings were completed with the aid of a camera lucida. All material is in the collections of the Australian Museum, Sydney (AM) or the Western Australian Museum (WAM); the number following the abbreviation of the institution is the registration number of the specimens.

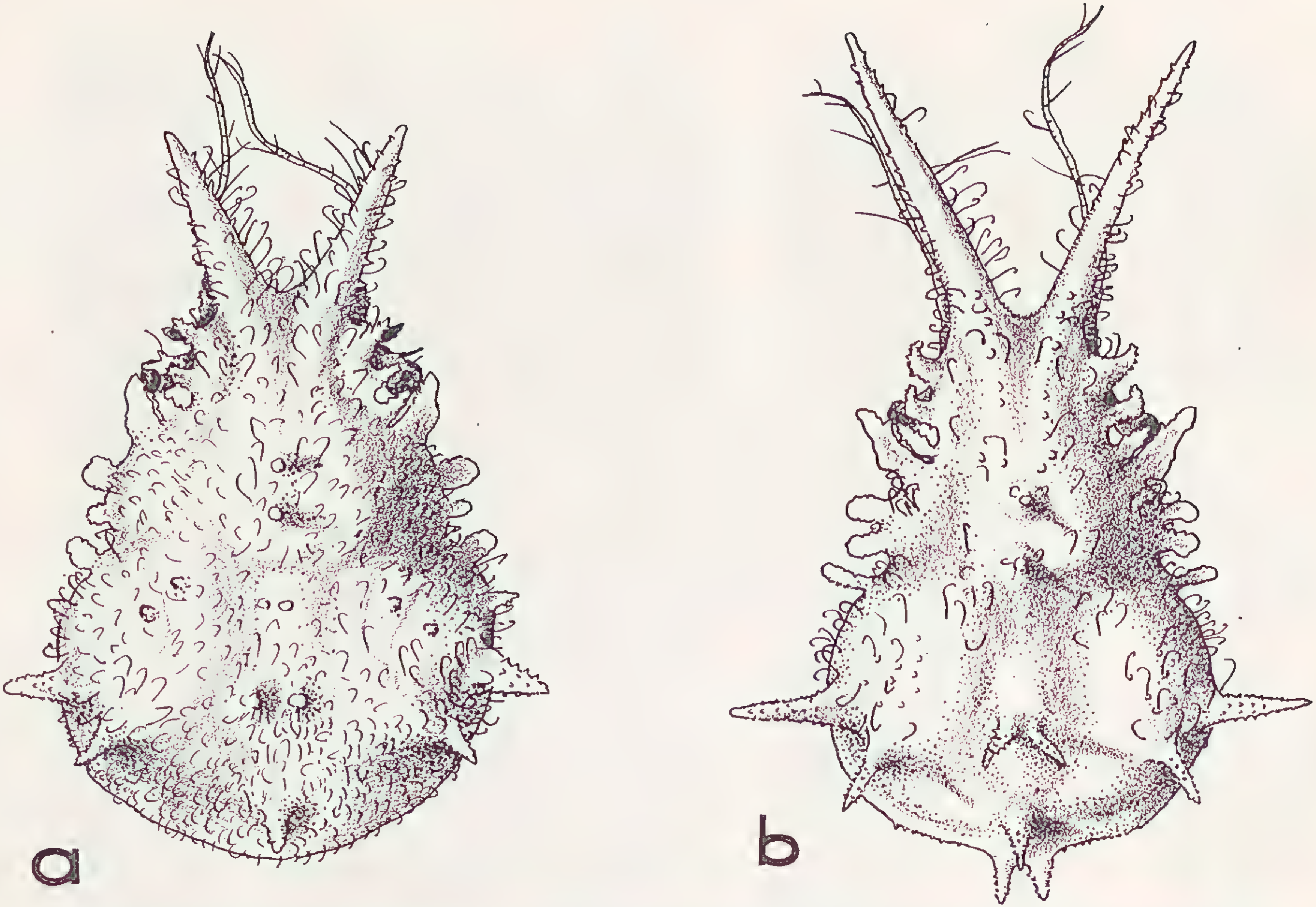


Fig. 1.—a *Chlorinoides goldsboroughi* Rathbun, 19.2 mm, male, 25 miles E. of Manly, near Sydney, N.S.W., 120–125 fms (AM P.13945); b *Chlorinoides occidentalis* n.sp., HOLOTYPE, male.

SYSTEMATICS

Family **MAJIDAE** Samouelle 1819

Genus **Chlorinoides** Haswell, 1880

Chlorinoides goldsboroughi Rathbun, 1906

(Figs. 1a, 2, 4b, c, f)

Chlorinoides goldsboroughi Rathbun, 1906: 881–882, pl. XIV fig. 7. Griffin 1966a: 4, 13; 1966c: 285 (in key).

Material examined

A total of 19 specimens as follows: 25 miles E. of Manly near Sydney, N.S.W., trawled, 120–125 fms, mud, A. A. Racek and Isobel Bennett on M.V. *Challenge*, 28–1–1960, 1 male, 19.2 mm (AM P.13945). 12–14 miles E. of Botany Bay, N.S.W. 90 fms, triangle dredge, CSIRO, *Derwent Hunter*, 4–5–1960, 1 male, 19.5 mm (AM P.16767). Off Cronulla, near Sydney, N.S.W., dredged, 160–200 metres, R. J. MacIntyre, 16–6–1965, 7 males, 8 females (all ovig.), 13.6–23.2 mm, smallest ovig. female 13.6 mm (AM P.16103). 12 miles E. of Wata Mooli, N.S.W., 78 fms, triangle dredge, CSIRO, *Derwent Hunter*, 28–4–1960, 1 male, 23.0 mm (AM P.15673). Lower N.S.W. coast, 70–75 fms, from net of trawler *Karanga* in port, M. Ward, 1924, 1 female (ovig.), 19.2 mm (AM P.7482).

Description

Carapace narrowly pyriform (postrostral length about 1.3 times width), margins and dorsal surface with a few short spines and lamellate lobes; surfaces densely granular, covered by short curled hairs, longer curled hairs along sides of rostral spines and around bases of carapace spines.

Rostrum of two moderately long spines (about one-third postrostral length of carapace), each straight or weakly inwardly curved, slender, cylindrical, acuminate, sharp, separate from close to base and widely divergent, distance between tips almost twice basal width of rostrum and slightly exceeding rostral length, numerous spinules along medial and lateral surfaces.

Orbit consisting above of supraorbital eave, intercalated spine and postorbital lobe, the three separated by U-shaped fissures, intercalated spine closer to postorbital lobe than to eave. Eave broad, bearing a short, flattened preorbital spine, directed outwards basally and slightly upwards at tip and a shorter, slightly broader, very weakly upwardly curved antorbital spine. Intercalated spine slightly exceeding antorbital spine in length and width, blunt apically. Postorbital lobe extending outwards beyond eave, flattened, subtriangular in shape, subtrigonal in section, posterior edge carinate, anterior surface weakly concave, margin dorsally fringed by long hairs. Edges and tips of preorbital, antorbital and intercalated spines spinulous, anterior edge of postorbital lobe dorsally bearing 2 or 3 spinules near tip. Eyestalk not quite reaching postorbital lobe, a small conical tubercle on anterior surface close to tip, cornea subterminal, somewhat ventral, circular, large.

Hepatic margin bearing two short, flattened, rounded, tuberculate lamellae, set obliquely, anterior the larger.

Branchial margin anteriorly with a lamella similar to anterior hepatic lobe followed by a short, tuberculate spine; two longer subdorsal spines posteriorly, anterior one at widest part of carapace the longer, both apically blunt and bearing small tubercles on their sides.

Dorsal surface of carapace with four short to moderately long, conical, apically blunt spines in midline, one on posterior part of mesogastric region, followed closely by a metagastric, a transverse, submedial divergent pair surmounting tumid cardiac region and one almost overlying posterior intestinal margin and directed weakly posteriorly. A pair of very small tubercles submedially on urogastric region and a similar pair sometimes on posterior intestinal margin. Two small tubercles laterally on branchial regions between mesogastric spine and largest marginal branchial spine.

Basal antennal article moderately broad, of more-or-less equal width throughout, anterolateral angle bearing a long, flattened lobe with tubercles on surface and anterior edge and spinules at tip, a shorter, conical, tuberculate lobe at anteromedial corner directed outwards and downwards; medial edge of article bearing a small elevation midway along. Antennae long, extending beyond rostrum, two stout, subequal, proximal segments together making up one quarter of this length, both proximal segments spinulous.

Antennular fossae large, subpentagonal. Basal two segments of antennules tuberculate, first elevated in midline. Interantennular spine blunt. Anterior process of epistome slender, reaching interantennular spine.

Epistome wider than long, a low elevation or small tubercle lateral to opening of green gland. Anterior edge and anterolateral corners of mouthfield carinate. Pterygostomian regions bearing a small tubercle midway along lateral margin. Subhepatic regions with three low tubercles laterally just ventral and anterior to marginal hepatic lobes.

Third maxillipeds with ischium large, subrectangular, longer than broad, medial half of distal edge produced anteriorly, anteromedial angle rounded, medial edge very coarsely toothed, overlaid but not concealed by a sparse fringe of long hairs; outer surface excavated medially as a very shallow, broad, longitudinal groove. Merus subcircular, slightly wider but shorter than, ischium, anterolateral angle outwardly produced, rounded, distal edge notched; outer surface weakly concave. Palp arising from notch of, and slightly longer than, merus, cylindrical, the three segments subequal, fringed by hairs, a dense array of long hairs at tip. Exognath granular, lateral edge densely hairy.

Sternum in male granular.

Chelipeds in male of moderate length (slightly exceeding carapace length), stout, cylindrical except for weakly compressed palm, naked, granular, ischium, merus and carpus tuberculate. Merus with about 15 tubercles, four or five weakly compressed ones laterally including large one on distal edge, six to eight small tubercles in an adjacent row on dorsal surface, and five large tubercles in a ventral row. Carpus with a weakly developed lateral ridge including three weakly compressed tubercles, three tubercles on medial surface and several on lateral surface. Chelae long, about half total length of cheliped, weakly inflated, palm slightly expanded midway along, almost twice as long as high, dorsal and ventral edges granular, proximally carinate; fingers short, dactyl slightly more than one-third chela length, gaping proximally, fixed finger excavate and bearing several small low teeth, dactyl bearing a large tooth projecting into gape, distal half of fingers coarsely toothed. Cheliped of female about as long as postrostral portion of carapace; chelae slender, palm tapering distally, fingers adjacent throughout their length.

Ambulatory legs moderately long, cylindrical, bearing a few scattered long simple hairs and short curled hairs in dense rows along all surfaces of meri, and in groups on dorsal surfaces of carpi and propodi, dense felt of short hairs on propodi ventrally and covering dactyls; round, blunt tubercles or spines in four, ill-defined,

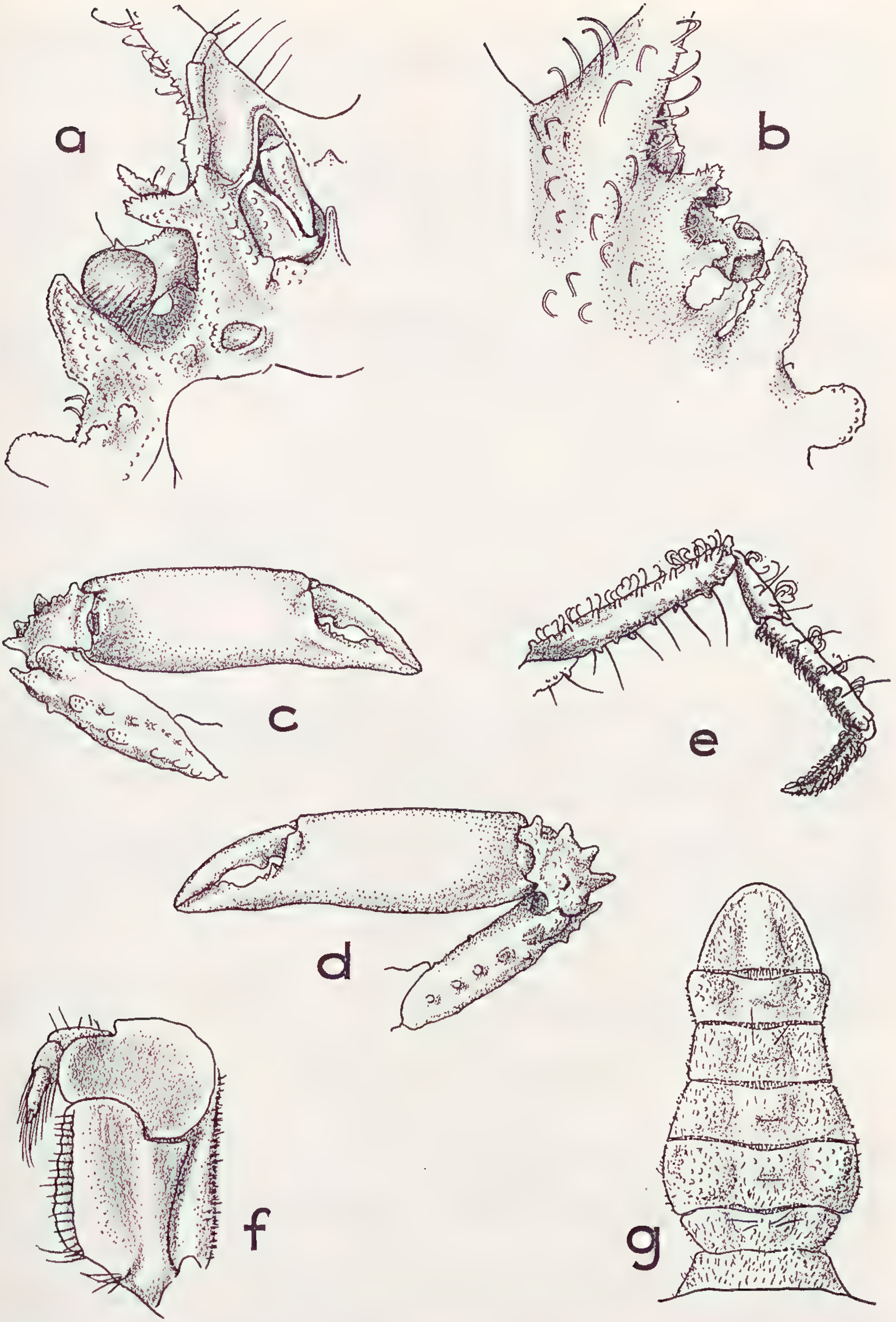


Fig. 2. — *Chlorinoides goldsboroughi* Rathbun, male (AM P.13945). a orbit, ventral view; b orbit dorsal view; c cheliped, inner view of chela; d cheliped, outer view of chela; e right first ambulatory leg, posterior view; f left third maxilliped; g abdomen.

longitudinal rows on meri, in two dorsal rows on carpi and in a single dorsomedial row on propodi; dactyls weakly curved, unarmed. First leg the longest, as long as total length of carapace, following legs decreasing uniformly in length, the last as long as postrostral portion of carapace.

Abdomen of seven distinct segments in both sexes. Male abdomen narrow, widest at base of third segment, following segments laterally concave to distal edge of sixth, seventh segment subtriangular, rounded distally. Segments wider than long, subequal in length except for slightly longer, seventh segment. Surface elevated distally in midline of each segment except last; third segment laterally elevated. Surface of abdomen granular.

Male first pleopod long, stout basally, tapering, slender and outwardly curved distally, tip pointed, aperture subterminal, lateral, covered by broad lateral flap; lateral surface bearing long simple hairs from near base of pleopod to base of flap, short simple hairs in row on lateral surface from tip of pleopod to base of flap, those adjacent to flap partly obscured by it, three or four on abdominal surface opposite flap, some short hairs on sternal surface near base of flap.

Measurements

Male (AM P.13945)—carapace length 19.2 mm, carapace width 11.3 mm, rostrum length 5.0 mm, rostrum width (base) 3.3 mm, cheliped 22.5 mm, chela length 13.5 mm, chela height 3.9 mm, dactyl 5.4 mm, first ambulatory leg ca 20.2 mm.

Ovigerous female (AM P.7482)—carapace length 19.2 mm, chela length 7.1 mm, chela height 1.8 mm, dactyl 3.4 mm.

Remarks

The most obviously variable features in this species include the relative sizes of the spines and tubercles on the carapace including those on the orbital border, chelipeds and ambulatory legs and the shape and relative length of the rostral spines.

These specimens agree in all diagnostic features with the original brief description and figure of the species by Rathbun.

Chlorinoides goldsboroughi appears to most closely resemble *C. brevispinosus* Yokoya, so far known only from the type localities (near Tanabe and east of Tanegasima, Japan). *C. brevispinosus*, however, has only a single mesogastric spine and there are four marginal branchial spines subequal in length.

Distribution

Hawaii; southeastern Australia. The presence of this species in Australia has previously been noted (Griffin 1966c: 285).

Chlorinoides occidentalis n.sp.

(Figs. 1b; 3; 4a, d, e)

Material examined.—A total of 30 specimens, as follows:

Holotype: 1 male, 17.1 mm, NW. of Rottnest Island, Western Australia, dredged, 85 fms, 15–8–1962, R. W. George on *Bluefin* (WAM 319–67).

Paratypes: 1 male, 14.1 mm, NW. of Bluff Pt, Geraldton, W.A., 27° 40′ S., 113° 03′ E., 70 fms, midwater trawl on bottom, 22–8–1963, HMAS *Diamantina* cruise 4–63, CSIRO Sta. 131 (WAM 204–67); 1 male, 1 female, 10.9, 13.5 mm (WAM 275–67). 1 female, 14.3 mm, NW. of Bluff Pt, Geraldton, W.A., 27° 40′ S., 113° 20′ E., beam trawl, 71½ fms, 10–10–1963, HMAS *Diamantina* cruise 6–63, CSIRO Sta. 208 (WAM 302–67). 1 female, 12.2 mm, SW. of Geraldton, W.A., 29° 05′ S., 113° 56′ E., triangle dredge, 71–81 fms, 16–2–1964, HMAS *Diamantina* cruise 1–64, CSIRO Sta. 54 (WAM 280–67). 1 female, 13.2 mm, W. of Lancelin Island, W.A., 31° 05′ S., 110° 55′ E., beam trawl, 62–67 fms, 5–2–1964, HMAS *Diamantina* cruise 1–64, CSIRO Sta. 46 (WAM 340–67). 1 male, 15.1 mm, NW. of Rottnest Island, W.A., 100–103 fms, R. W. George on *Bluefin*, 14–8–1962 (WAM 318–67); 1 male, 15.5 mm (WAM 341–67). 1 male, 16.0 mm, NW. of Rottnest Island, W.A., dredged, 85 fms, B. R. Wilson on *Bluefin*, 15–8–1962 (WAM 343–67). 1 female, ca 11.5 mm, WNW. of Rottnest Island, W.A., 80–90 fms, R. W. George on *Bluefin*, 14–8–1962 (WAM 344–67). 1 female (ovig.), 12.7 mm, W. of Rottnest Island, W.A., 32° 00′ S., 115° 16′ E., beam trawl, 75–78 fms, 12–10–1963, HMAS *Diamantina* cruise 6–63, CSIRO Sta. 225 (WAM 17–67); 11 males, 5 females, 10.9–15.1 mm (WAM 339–67—3 males, 1 ovig. female from this series now AM P.16822). 1 female, 12.2 mm, W. of West End, Rottnest Island, W.A., dredged, 85–95 fms, R. W. George on *Bluefin*, 12–8–1962 (WAM 342–67). 1 male, 13.4 mm, W. of West End, Rottnest Island, W.A., 80 fms, R. W. George on *Bluefin*, 10–8–1962 (WAM 338–67).

Description

Carapace narrowly pyriform (postrostral length about 1.4 times width), margins and dorsal surface with a few long spines and short lamellate lobes; surfaces smooth, bearing groups of long curled hairs laterally, around bases of spines and lobes and along sides of rostral spines.

Rostrum of two long spines (about one-half postrostral length of carapace in males, slightly shorter in females), each very weakly outwardly curved, slender, cylindrical, acuminate, pointed, separate from close to base and widely divergent, distance between tips almost three times basal width of rostrum and slightly exceeding rostral length; numerous spinules along medial and lateral surfaces.

Orbit consisting above of supraorbital eave, intercalated spine and postorbital lobe, the three separated by U-shaped fissures, intercalated spine closer to postorbital lobe than to eave. Eave broad, bearing a moderately long, acuminate, weakly flattened, upwardly curved preorbital spine and a slightly shorter, pointed antorbital lobe directed outwards basally, distal third directed abruptly upwards. Intercalated lobe flattened, elongate subovate, broad based. Postorbital lobe extending outwards beyond preorbital spine, flattened, subtriangular in shape, subtrigonal in section, posterior edge carinate, constricted at base, anterior surface weakly concave, anterior margin dorsally fringed by long hairs. Edges, tip and ventral surface of preorbital spine and edges and tips of antorbital and intercalated lobes spinulous, anterior edge of postorbital lobe dorsally bearing spinules along proximal two-thirds, most distal spinule longest, remainder of margin very minutely crenulate. Eyestalk reaching postorbital lobe, two small, conical tubercles and some stout hairs on anterior surface close to tip; cornea subterminal, somewhat ventral, circular, large.

Hepatic margin bearing two short, subequal, subovate, flattened lamellae with minutely spinulous margins, the first set slightly obliquely.

Branchial margin anteriorly with a subovate, obliquely set, minutely tuberculate lamella, slightly longer and narrower than hepatic lamellae and less strongly flattened, two very low conical tubercles immediately behind lamella; two long, slender, acuminate spines posteriorly subdorsally, subequal in length and covered by minute spinules.

Dorsal surface of carapace with seven straight, acuminate, spinulous spines in midline, one far back on mesogastric region followed closely by a metagastric, both very long, subequal in length to marginal branchial spines; two shorter, submedial, divergent spines transversely surmounting tumid cardiac region; a short, broad-based intestinal spine and a second pair of short, weakly-flattened, backwardly directed

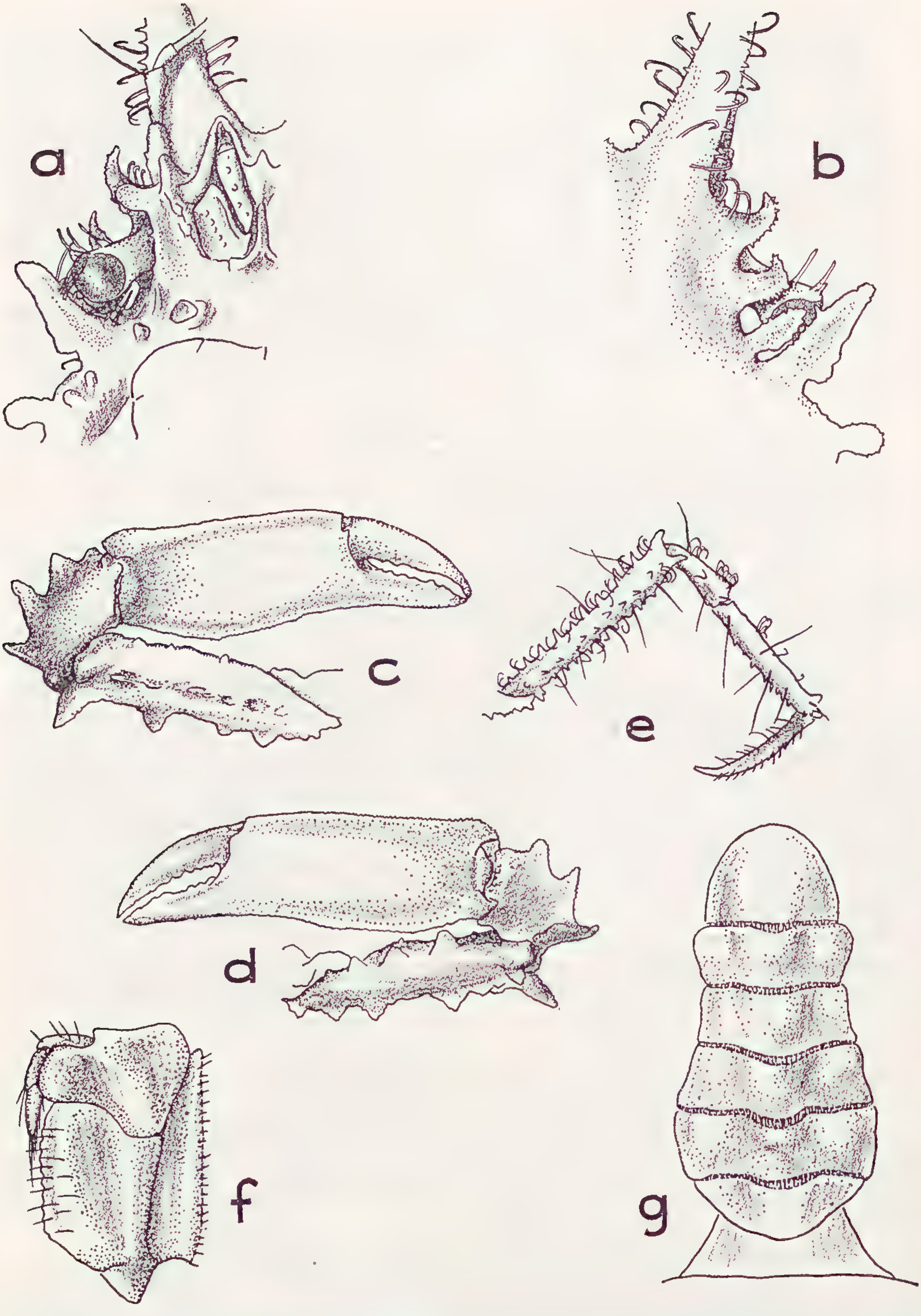


Fig. 3.—*Chlorinoides occidentalis* n.sp., HOLOTYPE, male. a orbit, ventral view; b orbit, dorsal view; c cheliped, inner view of chela; d cheliped, outer view of chela; e right first ambulatory leg, posterior view; f left third maxilliped; g abdomen.

spines overlying posterior margin. Protogastric regions with several low tubercles not far from midline. Several small tubercles in a group on branchial regions in front of posterior marginal spines.

Basal antennal article moderately broad, straight-sided, anterolateral angle bearing a short, broad, apically rounded, flattened lobe directed outwards, a similar but shorter, more conical, subacute lobe at anteromedial corner directed weakly outwards and downwards; lateral and medial edges of article weakly tuberculate, surface weakly concave. Antennae long, extending a little beyond rostrum, two subequal basal segments short, stout, together making up about one-seventh of length, both proximal segments spinulous.

Antennular fossae large, subpentagonal. Basal two segments of antennules tuberculate. Interantennular spine blunt. Anterior process of epistome extremely slender, reaching interantennular spine.

Epistome wider than long, a low elevation lateral and posterior to opening of green gland. Anterior edge and anterolateral corners of mouthfield carinate. Pterygostomian regions bearing a small tubercle midway along lateral border and a broad lobe posteriorly followed by a small tubercle. Subhepatic regions with three or four tubercles in a group immediately below and in front of anterior marginal hepatic lobe.

Third maxillipeds with ischium large, subrectangular, longer than broad, medial half of distal edge produced anteriorly, rounded, anteromedial angle obtuse, medial edge coarsely toothed, overlaid but not concealed by scattered long hairs; outer surface excavated medially as a very shallow, broad, longitudinal groove. Merus subquadrate, slightly wider but shorter than ischium, anterolateral edge weakly outwardly produced, anterolateral corner rounded, distal edge notched; outer surface with a low central ridge. Palp arising from notch of, and slightly longer than, merus, cylindrical, the three segments subequal, fringed by long hairs, a dense array of long hairs at tip. Exognath smooth, laterally bearing some stout hairs.

Sternum in male weakly tuberculate.

Chelipeds in male of moderate length (almost as long as total carapace length), stout, subcylindrical except for weakly compressed palm, naked, merus and carpus with several spinulous tubercles and minutely serrate lobes forming carinate ridges. Merus with a carinate, quadrilobate ridge laterally, a row of five tubercles along proximal half of dorsal surface followed by two larger compressed lobes, and three large tubercles in a ventral row, some small tubercles along dorsomedial surface; a large, compressed, subtriangular lobe laterally overlying distal edge. Carpus with a prominently quadrilobate ridge laterally and a low, tuberculate ridge, medially; some very low tubercles along dorsal surface. Chelae long, about half total length of cheliped, palm weakly inflated and slightly expanded about one-third along its length, almost twice as long as high, dorsal and ventral edges carinate and minutely serrate, outer surface weakly granular proximally. Fingers short, dactyl little more than one-third length of chela, inner edges weakly gaping in proximal half, coarsely toothed along entire length. Chelipeds in female short, about two-thirds postrostral length of carapace, ridges of merus and carpus less well-developed than in male, chelae slender, palm about three times as long as high, dorsal edge with small tubercles along proximal half, outer surface granular proximally, fingers very weakly gaping proximally.

Ambulatory legs moderately long, cylindrical, bearing a few scattered long and short curled hairs in rows on all surfaces of meri and in groups on dorsal surfaces of carpi and propodi, dactyls with short and long simple hairs more dense distally; ischia spinulous, meri, carpi and propodi all with stout spinules and tubercles of various lengths in three or four ill-defined longitudinal rows, three sharply pointed, spinulous, distal lobes on meri, one dorsal and one on each side and a similar lobe laterally and medially on distal edges of carpi, dactyls dorsally and ventrally tuberculate and spinulous, weakly curved. First leg the longest, about as long as carapace, following legs decreasing uniformly in length, the last as long as postrostral portion of carapace.

Abdomen of seven distinct segments in both sexes. Male abdomen narrow, widest at base of third segment, following segments tapering almost uniformly to rounded tip, sixth segment weakly laterally expanded distally, seventh segment semiovate. Segments 1–6 wider than long, subequal in length, seventh segment as long as wide. Surface elevated distally in midline of each segment except last and surmounted by a prominent tubercle which is bilobate in segments 4 to 6 and bears one or two long hairs; third segment laterally elevated. Surface of abdomen otherwise with a few tubercles. Female abdomen large, covering all of sternum in mature specimens.

Male first pleopod long, stout basally, tapering and outwardly curved distally, tip slender, pointed, aperture subterminal, lateral, covered by broad flap; lateral surfaces bearing long simple hairs in a row from near base of pleopod to base of flap, short simple hairs on abdominal surface laterally from tip of pleopod to base of flap, about six short hairs on medial part of abdominal surface opposite flap, some long and short hairs on sternal surface near base of flap.

Measurements

Male (holotype)—carapace length 17.1 mm, carapace width 7.7 mm, rostrum length 6.0 mm, rostrum width (base) 2.5 mm, cheliped ca 15.5 mm, chela length 7.9 mm, chela height 2.5 mm, dactyl 3.1 mm.

Female (WAM 302–67)—carapace length 14.3 mm, chela length 3.9 mm, chela height 0.8 mm, dactyl 1.9 mm.

Remarks

Although superficially similar to *Chlorinoides goldsboroughi*, the new species differs from it in about 20 features. *C. occidentalis* possesses only a single lobe on the anterior part of the branchial margin and two submedial intestinal spines on the posterior margin of the carapace. In addition, the carapace is slightly narrower, the rostral spines are relatively much longer and the distance between the tips greater, the antorbital lobe, intercalated spine, postorbital, hepatic and branchial lobes are of a different shape, the spines on the dorsal surface of the carapace and the subdorsal spines on the branchial margin are much longer, the shape of the anterolateral lobe of the basal antennal article and of the merus of the third maxilliped are different, the shape of the abdomen in the males and the details of the gape and ornamentation of the fingers of the cheliped in the male are different. The carapace in *C. occidentalis* bears groups of curled hairs whereas in *C. goldsboroughi* the curled hairs are not in groups, *C. occidentalis* is much more spinulous, the protogastric and branchial regions are more tuberculate and the crests on the cheliped are more strongly developed. Finally, there are remarkably slight but definite differences between the two species in the shape and ornamentation of the first pleopod in the male with respect to curvature, slenderness of the distal portion, shape of the flap and arrangement of hairs distally.

Distribution: Southwestern Australia.

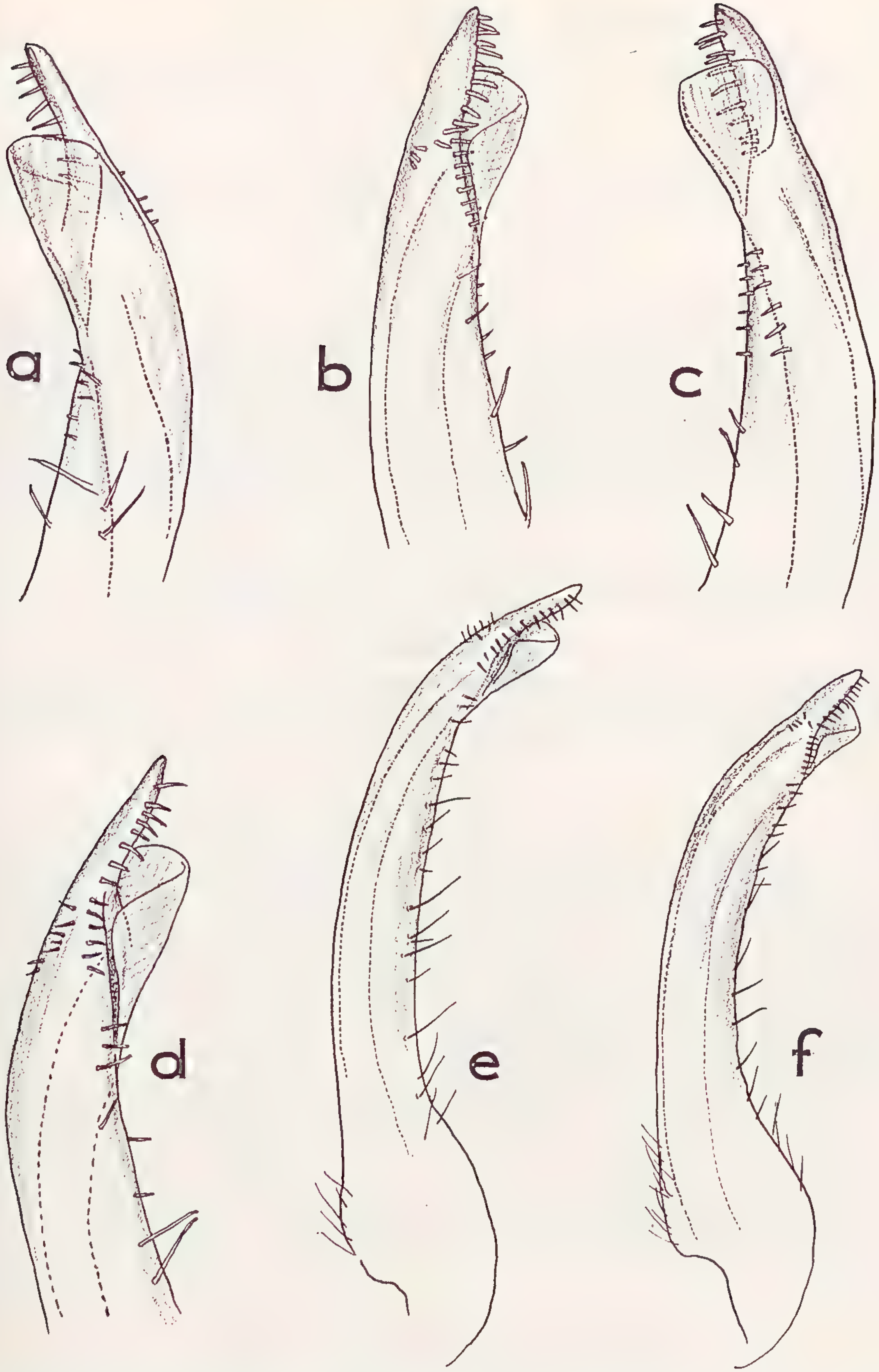


Fig. 4.—Male left first pleopod of *Chlorinoides occidentalis* n.sp., HOLOTYPE (a, d, e) and *Chlorinoides goldsboroughi* Rathbun (AM P.13945) (b, c, f). a, c tip, sternal view; b, d tip, abdominal view; e, f whole pleopod, abdominal view.

Chlorinoides tenuirostris Haswell, 1880

Chlorinoides tenuirostris; Griffin, 1966a: 4, 6–9, 12, figs 2–11; 1966b: 82 (in key); 1966c: 285 (in key).

Material examined

SW. of Point Cloates, W.A., 23° 05′ S., 113° 23′ E., 73 fms, triangle dredge, 7–10–1963, HMAS *Diamantina* cruise 6–63, CSIRO Sta. 182, 1 female, 31.8 mm (WAM 99–67).

Remarks

This specimen agrees in all important features with the material previously reported on by Griffin (1966a). The only differences are that the spinule on the dorsal surface of the rostral spines is halfway between the base and the tip, the anterior part of the carapace is dorsally more convex, there are three short, subequal spines in the midline of the mesogastric region and two short spines in the midline in the cardiac region, the posterior one slightly longer, the spine on the hepatic margin is short and the subhepatic spine is also short and the lobe on the posterior edge of the postorbital lobe is large so that the tip of the latter appears subtruncate.

Distribution

Restricted to Australia, previously known from Darnley Island to Cape Grenville, northern Queensland and now recorded from Western Australia.

ACKNOWLEDGMENTS

I wish to thank Dr J. C. Yaldwyn, formerly of the Australian Museum, and Dr R. W. George, Western Australian Museum, for advice in the early stages of this study. Examination of the collections of the Western Australian Museum was made possible by a research grant from the CSIRO Science and Industry Endowment Fund.

REFERENCES

Griffin, D. J. G., 1966a. The genus *Chlorinoides* (Crustacea, Brachyura, Majidae). I. A redescription of *C. tenuirostris* Haswell and the status of the genus *Acanthophrys* A. Milne Edwards. *Rec. Aust. Mus.* 27: 1–16, 11 figs.

Griffin, D. J. G., 1966b. The marine fauna of New Zealand: spider crabs, family Majidae (Crustacea, Brachyura). *Bull. N.Z. Dep. scient. ind. Res.* 172: 1–112, 23 figs, 4 pls.

Griffin, D. J. G., 1966c. A review of the Australian majid spider crabs (Crustacea, Brachyura). *Aust. Zool.* 13: 259–298, 3 figs, pls XV–XVII.

Rathbun, Mary J., 1906. The Brachyura and Macrura of the Hawaiian Islands. *Bull. U.S. Fish. Comm.* 23: 827–930, 79 figs, pls 3–25.

Sakai, T., 1938. Studies on the crabs of Japan. III. Brachygnatha, Oxyrhyncha: 193–364, 55 figs, pls XX–XLI Tokyo: Yokendo Co.

Sakai, T., 1965. The crabs of Sagami Bay collected by His Majesty The Emperor of Japan. Tokyo: Maruzen. Pp. i–xvi, 1–206, 1–26 (English), 1–92, 27–32 (Japanese), 26 figs, 100 pls, 1 map.

Yokoya, Y., 1933. On the distribution of decapod crustaceans inhabiting the continental shelf around Japan, chiefly based upon the materials collected by S.S. *Sôyô-Maru*, during the year 1923–1930. *J. Coll. Agric. Tokyo Imp. Univ.* 12: 1–226, 71 figs.

V. C. N. Blight, Government Printer, New South Wales—1970

TWO NEW STOMATOPOD CRUSTACEANS FROM AUSTRALIA

By Raymond B. Manning

Smithsonian Institution, Washington, D.C., U.S.A.

Figures 1 and 2 Manuscript received, 20th February, 1969

Late in 1968 John C. Yaldwyn, then Curator of Crustacea at the Australian Museum, forwarded three small stomatopods from the collections of that Museum to me for study. One of the specimens proved to be a juvenile of a previously known Australian species, *Anchisquilla mcneilli* (Stephenson); it differs enough from published accounts of larger specimens to justify inclusion here of some descriptive notes. Both of the other specimens represent undescribed species belonging to two genera already recorded from Australian waters, *Heterosquilla* (Family Lysiosquillidae) and *Manningia* (Family Gonodactylidae); both of the new species are described herein.

I am indebted to Dr Yaldwyn for bringing these specimens to my attention and making them available for study. The drawings were made by my wife Lilly.

Descriptive terms used herein have been explained in detail in an earlier paper (Manning, 1966). All of the specimens have been deposited in the Australian Museum.

Family **GONODACTYLIDAE** Giesbrecht, 1910

Genus **Manningia** Serène, 1962

The current composition of this genus attests to our limited knowledge of the species of stomatopods. When *Manningia* was recognized by Raoul Serène in 1962 it contained but one species, *M. pilaensis* (de Man, 1888). In 1966 I described the second species, *M. notialis*, from the coasts of northeastern Australia, and in 1967 I described a new species from Viet-Nam, *M. serenei.* In the same paper I pointed out that another specimen recorded in the literature from the Gulf of Aden probably represented a distinct species. L. B. Holthuis described that species in 1967 as *M. amabilis*; all of his material was from the Red Sea. Holthuis also reported an extension of the range of *M. pilaensis* to Bombay, India, from where it subsequently was recorded by Chhapgar and Sane (1968); that species had not been recorded previously from localities west of the Mergui Archipelago, Burma, the type-locality. The range of *M. amabilis* was extended to western West Pakistan by Tirmizi and Manning (1968).

In addition to the new species described herein, *M. australiensis*, there is another undescribed species which occurs in the Gulf of Guinea; a description of the West African species, the first representative of the genus to be found outside of the Indo-West Pacific region, is in preparation in a review of the West African stomatopod fauna.

The six known species of *Manningia* may be distinguished by means of the following key:

Key to Species of Manningia

1. Basal prolongation of uropod lacking rounded lobe between apical spines 2
Rounded lobe present between apical spines of basal prolongation of uropod 4

2. Rostral plate with apical spine; merus of raptorial claw with inferodistal spine on outer face ....
M. pilaensis (de Man, 1888); China, Mergui Archipelago, Bombay.
Rostral plate without apical spine; outer face of merus of claw unarmed 3

3. Rostral plate broadly rounded anteriorly and anterolaterally; fifth abdominal somite with posterolateral spine ....
M. amabilis Holthuis, 1967; Red Sea, Gulf of Aden, West Pakistan.
Rostral plate bluntly angled anteriorly and anterolaterally; fourth and fifth abdominal somites each with posterolateral spine ....
M. notialis Manning, 1966; northeastern Australia.

4. Fifth abdominal somite with 2 spines on posterior margin, above posterolateral angle ....
Manningia n. sp.; Gulf of Guinea.
Fifth abdominal somite not armed above posterolateral angle 5

5. Outer face of merus of raptorial claw with inferodistal spine; rostral plate angled anterolaterally; intermediate carinae of telson anteriorly separate from laterals ....
M. serenei Manning, 1967; Viet-Nam.
Outer face of merus of raptorial claw unarmed; rostral plate broadly rounded anterolaterally; intermediate carinae of telson fused anteriorly with laterals ....
M. australiensis new species.

Manningia australiensis new species

Fig. 1

Holotype.—1♀, 32 mm; off Gillett Cay, Swains Reefs, Queensland; dredged; 35–40 fms; Swain Reef Expedition, Australian Museum party; October, 1962; reg. no. P. 16288.

Description:

Cornea bilobed, outer margin of eye longer than inner (fig. 1*a*); eyes not extending to end of first segment of antennular peduncle; ocular scales low, fused medially.

Antennular peduncles elongate, more than four-fifths as long as carapace.

Antennal scale slender, slightly curved, almost half as long as carapace, margins completely lined with setae; antennal protopod with 1 ventral papilla.

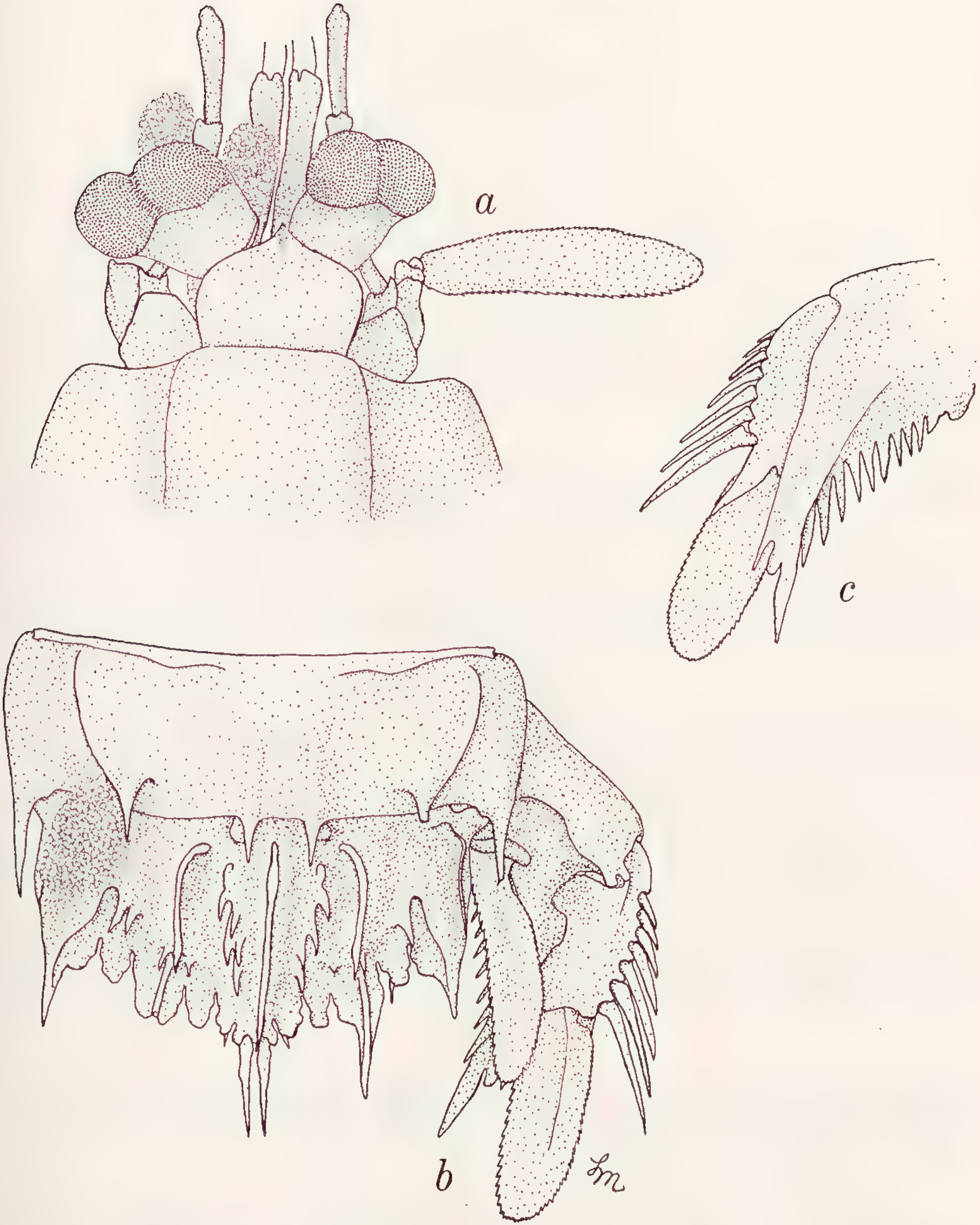


Figure 1.—*Manningia australiensis* new species, female holotype. *a*, anterior portion of body; *b*, last abdominal somite, telson, and uropod; *c*, uropod, ventral view. (Setae omitted).

Rostral plate (fig. 1*a*) cordiform, broader than long, evenly rounded laterally; short apical spine present; shallow, longitudinal, median groove present on anterior fourth.

Carapace smooth, narrowed anteriorly, anterolateral angles rounded; reflected marginal carinae present posterolaterally.

Raptorial claw stout; dactylus with 4 teeth, outer margin with prominent basal notch; propodus broad, superior margin fully pectinate; carpus with 2 teeth on upper margin; merus lacking inferodistal spine on outer margin.

Mandibular palp and 5 epipods present.

Lateral process of fifth thoracic somite inconspicuous, concealed under posterolateral angles of carapace; lateral processes of sixth and seventh thoracic somites rounded laterally; endopods of walking legs two-segmented, distal segment ovate on first 2 legs, slenderer on last; median ventral keel of eighth thoracic somite very low, inconspicuous.

Abdomen smooth, flattened, distinct carinae present on last 3 somites only; fourth and fifth somites each with lateral carina above lateral, longitudinal groove, carinae on fifth somite longer, better defined; first 5 abdominal somites unarmed; sixth somite (fig. 1*b*) with 3 pairs of posterior spines, intermediates set anterior to posterior margin; submedian spines with low, inconspicuous longitudinal carinae, outer margin of intermediate teeth strongly carinate; dorsal surface of sixth somite smooth between submedian and intermediate carinae; sixth somite with ventrolateral spinule anterior to articulation of each uropod.

Telson (fig. 1*b*) almost twice as broad as long, with 3 pairs of marginal teeth, submedians movable, with bases appressed; intermediate and lateral teeth slender, sharp, each with short dorsal carina; submedian denticle absent; 2 broad intermediate denticles present, outer with ventral spinule, inner spined distally; 2 broad lateral denticles, with ventral spinule, present; each ventral spine with rounded lobe present dorsally between apex and point of origin on ventral surface of telson, lobe visible only in lateral view; median carina slightly inflated anteriorly, terminating posteriorly in slender spine; accessory median carinae interrupted, subdivided into 4 or 5 erect spinules in irregular, curved row; submedian carinae entire, terminating in distal spine, apex flanked posteriorly by outer spinule and inner denticle; intermediate carinae reduced, present as long spine connected anteriorly to lateral carina by curved ridge; apical spine flanked by spinule on 1 side; lateral and marginal carinae both entire.

Uropod (figs 1 *b*, *c*) with 7 slender movable spines on outer margin of proximal segment of exopod, distalmost extending beyond midlength of distal segment; endopod slender, curved; basal prolongation of uropod with 9–10 fixed spines on inner margin and broad, rounded lobe between distal spines.

Colour.—Pattern almost completely faded in type; carapace with pair of dark spots anteriorly on gastric grooves, transverse bar of dark pigment on posterior third, and dark area along posterolateral angles; thoracic and anterior abdominal somites with few scattered dark chromatophores medially; sixth abdominal somite with traces of dark pigment along carinae; telson with traces of dark spots between dorsal carinae and along lateral margin.

Measurements.—Female holotype, only known specimen, total length 32 mm. Other measurements, in mm: carapace length 6.8; cornea width 1.9; rostral plate length 1.5, width 2.0; fifth abdominal somite width 7.0; telson length 2.8, width 5.3.

Etymology.—The name alludes to the occurrence of the species in Australian waters.

Discussion:

M. australiensis can be distinguished from the other known species in the genus by the shape of the rostral plate, which is cordiform in outline with rounded lateral margins and a short apical spine. It shares the rounded lobe between the apical spines of the basal prolongation of the uropod with *M. serenei* and the undescribed species known from the Gulf of Guinea, and it differs from the other known species, *M. amabilis*, *M. notialis*, and *M. pilaensis*, in this feature. The new species from the Gulf of Guinea can be distinguished from *M. australiensis* by the posterior spines present on the fifth abdominal somite.

M. australiensis shares the unarmed inferodistal angle of the merus of the claw with *M. notialis*, *M. amabilis*, and the West African species; the merus is armed in both *M. pilaensis* and *M. serenei*. Although the unique holotype is slightly damaged, all of the diagnostic features are readily discernible.

The body of the holotype is covered with numerous ovate, stalked bodies which appear to be egg capsules containing a fine, granular yolk; the capsules are about 1.6–2.0 mm high and 0.6–1.0 mm in diameter. Two of the capsules are shown in fig. 1*a*, under the left eye, and one is shown in fig. 1*b*, attached to the surface of the sixth abdominal somite. The origin of these attached bodies is unknown.

Distribution.—Known only from the type-locality off Gillett Cay, Swains Reefs, Queensland, Australia.

Family **LYSIOSQUILLIDAE** Giesbrecht, 1910

Heterosquilla (**Heterosquilloides**) **insueta** new species

Fig. 2

Holotype.—1♂, 23 mm; Great Australian Bight, Western Australia; 33° 43′ S, 125° 04′ E; 77 m; CSIRO Fisheries, col.; 7th July, 1962; reg. no. P. 16286.

Description:

Eye small, cornea bilobed, set almost transversely on stalk; eyes extending anteriorly to midlength of antennular peduncle; ocular scales small, rounded, fused medially.

Antennular peduncle slightly more than half as long as carapace; antennular processes visible lateral to rostral plate as sharp, anteriorly-curved spines.

Antennal scale small, less than half as long as carapace; no papillae visible on antennal protopod.

Rostral plate (fig. 2*a*) with short, broad basal portion, rounded laterally, and long apical spine, extending beyond eyes; apical spine carinate dorsally, lacking subapical ventral spine.

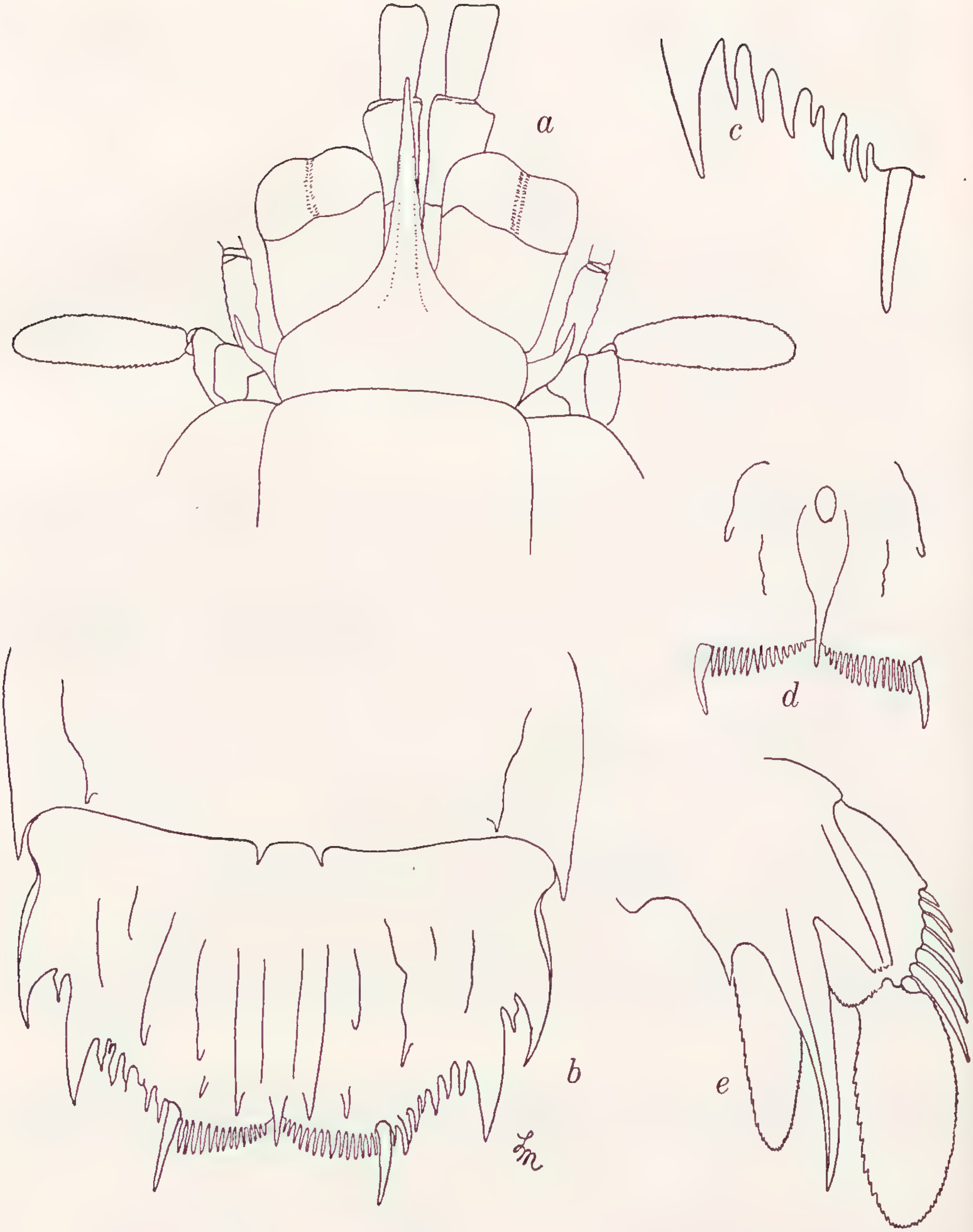


Figure 2.—*Heterosquilla* (*Heterosquilloides*) *insueta* new species, male holotype. *a*, anterior portion of body; *b*, last abdominal somite and telson; *c*, intermediate denticles of right side, ventral view, enlarged; *d*, meridian portion of ventral surface of telson; *e*, uropod, ventral view. (Setae omitted.)

Carapace smooth, short, narrowed anteriorly, without carinae or spines.

Dactylus of raptorial claw with 6 teeth, outer margin flattened, with prominent basal notch; propodus slender, upper margin fully pectinate; dorsal ridge of carpus terminating in slender spine; ischium and merus of claw unarmed.

Mandibular palp and five epipods present.

Fifth thoracic somite lacking prominent lateral process; lateral processes of sixth and seventh somites flattened laterally, rounded anterolaterally, more angled posterolaterally, process of seventh somite larger than that of sixth; basal segments of walking legs each with posterior ventrally-directed spinule; endopods of walking legs two-segmented, distal segment subcircular on first leg, more ovate on second, very slender on third; eighth somite lacking noticeable median ventral keel or prominence.

Abdomen smooth, depressed, first 5 somites unarmed; sixth somite (fig. 2*b*) with 3 pairs of dorsal spines, small submedians and longer laterals on posterior margin, intermediates each at end of short, curved carina, apical spine anterior to posterior margin; sixth somite with broad, triangular lobe in front of articulation of each uropod.

Telson (fig. 2*b*) badly damaged on type, apparently with raised median area, terminating in posterior median spine; dorsal surface with 6 longitudinal carinae between midline and marginal carina, length variable, fifth shortest, second, third and fourth terminating in apical spines; surface of telson also ornamented with denticle set posteriorly to third carina, and, possibly, an anterolateral tubercle between intermediate and lateral spines of sixth abdominal somite; 3 pairs of marginal teeth present, submedians movable; 14–15 slender submedian denticles present, arranged in convex row on each side of midline, inner denticles smaller than outer; 7–8 intermediate denticles (fig. 2*c*) present; anal pore on ventral surface (fig. 2*d*) flanked posteriorly by prominent median spine and laterally by 2 pairs of short carinae, outermost each terminating in short spine.

Basal segment of uropod with dorsal carina extending toward dorsal spine; 7 movable spines present on outer margin of uropodal exopod, distalmost extending beyond midlength of distal segment; inner, distal angle of proximal segment of exopod with 9 stiff setae; distal segment of exopod longer than proximal; endopod short, triangular, proximal portion of outer margin with slight fold; inner spine of basal prolongation of uropod much longer than outer (fig. 2*e*), both with ventral keel; slender spine present proximally at articulation of endopod.

Colour.—The colour pattern has completely faded in the holotype.

Measurements.—Unique male holotype, total length 23 mm. Other measurements, in mm: carapace length 4.7; cornea width ca. 1.2; rostral plate length 2.4, width 1.8; telson length 2.0, width 3.9.

Etymology.—The name is from the Latin, insuetus, meaning unusual, alluding to the large number of intermediate denticles on the margin of the telson.

Discussion:

Heterosquilla insueta basically resembles *H. brazieri* (Miers) and *H. latifrons* (de Haan) in such features as shape of eye, shape of rostral plate, presence of six teeth on the claw, and the postanal spine. It can be distinguished readily from both *H. brazieri* and *H. latifrons* by the absence of a subapical ventral spine on the rostral plate and the occurrence of the three pairs of spines on the sixth abdominal somite. The presence of these spines on the sixth abdominal somite, the large number of intermediate denticles on the telson, and the postanal spine will immediately distinguish *H. insueta* from all other species in the genus.

Although the holotype of *H. insueta* is in relatively poor condition, with the eyes, abdomen, and telson all damaged, the features which distinguish it from other species are clearly discernible. It is possible that a specimen with an intact telson would exhibit dorsal ornamentation different from that recorded here.

None of the species of the subgenus *Heterosquilloides* known until now have had more than four intermediate denticles on the telson, so *H. insueta* is unique in the subgenus in this respect. The original subgeneric diagnosis given by me (1966, p. 124) should be amended to "4 or more intermediate denticles on telson." Species in the nominate subgenus have but two intermediate denticles on the telson.

The type is obviously a juvenile, for the male copulatory tubes are poorly developed, but it seems unlikely that its major diagnostic features will change with age. The postanal spine, dorsal spines on the sixth abdominal somite, and teeth on the dactylus of the claw are not features that normally change after the postlarval stage. Features of this specimen which could change with age are the length of the rostral spine, the configuration of carinae on the telson, and the position of the marginal denticles of the telson.

Most species of *Heterosquilla* have one or more papillae on the antennal protopod; I can find no papilla on the holotype of *H. insueta*. Nothing is known about the development of this papilla, and it may develop at a later stage.

This is the third species of *Heterosquilla* to be recorded from Australasian waters. *H. tricarinata* and *H. brazieri* were both redescribed by me in 1966.

Distribution.—Known only from the type-locality, 33° 43′ S, 125° 04′ E, in the Great Australian Bight, Western Australia.

Family **SQUILLIDAE** Latreille, 1803

Anchisquilla mcneilli (Stephenson, 1953)

Squilla mcneilli Stephenson, 1953, p. 213, fig. 4.—Manning, 1966, p. 99 [other references]; 1968, p. 127 [listed; transferred to *Anchisquilla*].

Material.—1♀, 25 mm; off Cronulla, near Sydney, New South Wales, Australia; dredged; 100 m; R. J. MacIntyre, CSIRO; October, 1964; reg. no. P. 16279.

Remarks.—This small juvenile female, which is about 20 mm smaller than any specimens reported to date, differs from adults in several features. The apex of the rostral plate is more acute, and, when the plate is deflexed, the sharp median carina appears as a small apical spine. The cornea is noticeably more inflated. The carapace completely lacks the median carina, and the carinae of the thoracic and abdominal somites are not nearly so well developed as in adults. The spination of the abdominal carinae is reduced, for none of the carinae anterior to the fourth somite are armed posteriorly; in adults the intermediate carinae of the second to sixth somite are all provided with spines, and the lateral and marginal carinae of all of the somites are armed. Finally, the juvenile differs from adults in having a much more prominent lobe between the spines of the basal prolongation of the uropod.

Neither Stephenson (1953) nor Manning (1966) mentioned the very prominent falcate ventral spine on the midline of the eighth thoracic somite.

In other respects, including the colour pattern, this specimen agrees well with accounts in the literature.

The species is known from numerous localities off New South Wales and from Western Australia, in depths between 46 and 164 meters.

LITERATURE CITED

Chhapgar, B. F., and Sane, S. R. (1968). The Stomatopoda of Bombay. *Journ. Biol. Sci.*, **9** (1–2) (1966): 43–46.

Holthuis, L. B. (1967). The stomatopod Crustacea collected by the 1962 and 1965 Israel South Red Sea Expeditions. The Second Israel South Red Sea Expedition, Report No. 1. *Israel J. Zool.*, **16**: 1–45, figs 1–7.

Manning, Raymond B. (1966). Notes on some Australian and New Zealand stomatopod Crustacea, with an account of the species collected by the Fisheries Investigation Ship *Endeavour*. *Rec. Aust. Mus.*, **27** (4): 79–137, figs 1–10.

——— (1967). Notes on the genus *Manningia* with description of a new species (Crustacea: Stomatopoda). *Proc. U.S. Nat. Mus.*, **122** (3589): 1–13, figs 1–3.

——— (1968). A revision of the family Squillidae (Crustacea, Stomatopoda), with the description of eight new genera. *Bull. Mar. Sci.*, **18** (1): 105–142, figs 1–10.

Serène, R. (1962). Révision du genre *Pseudosquilla* (Stomatopoda) et définition de genres nouveaux. *Bull. Inst. Océanogr. Monaco*, no. 1241: 1–27, figs 1–5.

Stephenson, W. (1953). Three new Stomatopoda from eastern Australia. *Australian J. Mar. Freshw. Res.*, **4** (1): 201–218, figs 1–4.

——— (1962). Some interesting Stomatopoda—mostly from Western Australia. *J. Roy. Soc. Western Australia*, **45** (2): 33–43, figs 1–2, pl. 1.

Tirmizi, Nasima M., and Manning, Raymond B. (1968). Stomatopod Crustacea from West Pakistan. *Proc. U.S. Nat. Mus.*, **125** (3666): 1–48, figs 1–17.

INTERTIDAL ALCYONARIANS IN THE VICINITY OF DARWIN, NORTHERN TERRITORY, AUSTRALIA*

By Huzio Utinomi

Seto Marine Biological Laboratory, Kyoto University, Sirahama, Japan

Plates 15 and 16. Text-figures 1–12. Manuscript received, 27th December, 1968.

ABSTRACT

The octocorals, mostly soft alcyonaceans which were collected by Miss Elizabeth C. Pope on the shore reefs near Darwin, northern Australia, during her ecological survey made between 1965 and 1967, are treated systematically in this paper. In all, seventeen known species are listed here. Of the alcyonaceans, two species belong to *Lobophytum*, four to *Sarcophyton*, and one to *Sinularia;* these are all the members of Alcyoniidae and are well-known main reef-builders widespread on the Indo-West Pacific coral reefs. Of the remaining Nephtheidae, six species of *Stereonephthya*, one species of *Dendronephthya* and one species of *Nephthea* were obtained and observed rather commonly in the intertidal zone near Darwin; some of these nephtheid octocorals are easily observed here to form colourful zonation around the reef at low tide.

Although the amount of material available for the study of the local fauna was limited, now it became clear that there was much confusion concerning the nomenclature of common tropical Australian alcyonarians in earlier decades, mainly due to the lack of free currency of literature concerned and the paucity of actual exploration in the field.

INTRODUCTION

The octocorals, mostly alcyonaceans, treated in this paper, were collected by Miss Elizabeth C. Pope, Curator of Worms and Echinoderms at the Australian Museum, on the shore reefs near Darwin, Northern Territory, Australia, during her ecological survey in October, 1965, and, supplementally, by Mr A. J. Boase, her field assistant, in October, 1966, and September–October, 1967.

Most of the specimens entrusted to me for identification are confined to the inhabitants of intertidal reef flat or reef margin, except only one subtidal gorgonacean (*Euplexaura nuttingi* Kükenthal). Though the collection is limited, it contains unexpectedly many species of *Stereonephthya*, besides leathery alcyonaceans prevalent on the Indo-Pacific coral reefs. All of them have already been recorded from the neighbouring areas; some of them seem to be very common and abundant there, showing colourful zoning communities at low tide.

I am much obliged to Dr F. H. Talbot, Director of the Australian Museum and Editor of its publications, for permitting this paper in the *Museum's Records*, and, particularly, to Miss Elizabeth C. Pope, for entrusting me with this interesting collection, together with pertinent ecological comments. My thanks are also due to Mr Chuichi Araga, of our laboratory, for taking the photographs.

---

* Contribution from the Seto Marine Biological Laboratory, Kyoto University, No. 548.

SPECIES REPRESENTED IN THE COLLECTION

Subclass **OCTOCORALLIA** Haeckel, 1866

Order **STOLONIFERA** Hickson, 1883

Family Tubiporidae Ehrenberg, 1828

1. *Tubipora musica* Linné, 1758

Order **ALCYONACEA** Lamouroux, 1816

Family Alcyoniidae Lamouroux, 1812

2. *Lobophytum pauciflorum* (Hemprich and Ehrenberg, 1834)
3. *Lobophytum crassospiculatum* Moser, 1919
4. *Sarcophyton moseri* Roxas, 1932
5. *Sarcophyton ehrenbergi* Marenzeller, 1886
6. *Sarcophyton glaucum* (Quoy and Gaimard, 1833)
7. *Sarcophyton trocheliophorum* Marenzeller, 1886
8. *Sinularia polydactyla* (Hemprich and Ehrenberg, 1834)

Family Nephtheidae Gray, 1862 (emend. Utinomi, 1954)

9. *Nephthea chabrolii* Audouin, 1828
10. *Stereonephthya whiteleggi* Kükenthal, 1905
11. *Stereonephthya costatofulva* (Burchardt, 1898)
12. *Stereonephthya costatocyanea* (Burchardt, 1898)
13. *Stereonephthya longicaulis* Kükenthal, 1911
14. *Stereonephthya armata* Kükenthal, 1910
15. *Stereonephthya bellissima* Thomson and Dean, 1931
16. *Dendronephthya* (*Morchellana*) *spinosa* (Gray, 1862)

Order **COENOTHECALIA** Bourne, 1895

Family Helioporidae Moseley, 1876

17. *Heliopora coerulea* (Pallas, 1766)

SYSTEMATIC ACCOUNT

STOLONIFERA

Genus **Tubipora** Linné, 1758

Tubipora musica Linné, 1758

For description and literature see: Wright, 1869, p. 377, pl. 23; Hickson, 1883, p. 556, with 14 figs.

Material.—Not examined directly by the author.

Habitat.—Found only at Dudley Point, Darwin, where it was growing near the inner side of the very wide reef-flat dominated by brain corals (such as *Leptoria* and *Platygyra*). The growths were miserably small and stunted. This contrasted greatly with the fine growths of *Tubipora musica* one finds on the Pacific coast of Australia. In fact, I would say it was almost absent along the northern Australian coast (after a personal communication from Miss Pope, 11th April, 1967).

Distribution.—Previously recorded from various localities in the Red Sea, the Indian Ocean and the tropical Pacific Ocean, as far north as Garanbi, southernmost cape of Formosa (Utinomi, 1959, p. 304). Earlier record of occurrence from the West Indies seems to be due to misidentification.

ALCYONACEA

Genus **Lobophytum** Marenzeller, 1886

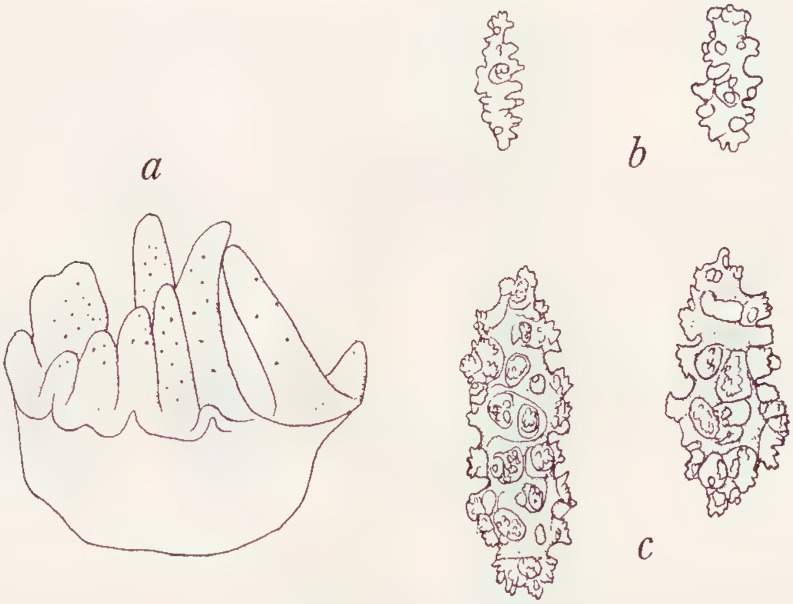
Lobophytum pauciflorum (Hemprich and Ehrenberg, 1834)

(Text-fig. 1; pl. 15, fig. 2)

For principal literature see: Tixier-Durivault, 1958, p. 127, figs 138, 141 and 142; Verseveldt, 1960, p. 218.

Material.—Coll. no. 3: A small colony. Fannie Bay, Darwin, on rocks near muddy shore. Coll. J. Boase and E. C. Pope, 11th October, 1965. Coll. no. 10: A small colony. Dudley Point, Darwin, in pools in muddy zone. Coll. E. C. Pope, 14th October, 1965.

Colour in life.—Browny-green. When preserved in alcohol after narcotization, turned to light grey or greyish-white.



Text-fig. 1.—*Lobophytum pauciflorum* (Hemprich and Ehrenberg). *a*, a small colony with digitate lobes (coll. no. 10), side view; *b*, spicules from stalk cortex; *c*, spicules from stalk interior. (*a*, × $\frac{2}{3}$, *b–c*, × 110.)

Description.—The first-mentioned specimen (coll. no. 3) is 3 cm in height and the upper disc is deeply depressed in the centre, and marginally lobed with widely separated broad lobes of which the largest one is 4 cm high, 2 cm wide and 5 mm in thickness. In the other specimen (coll. no. 10, text-fig. 1), on the other hand, the lobes are all narrow digitiform, approximately 10–25 mm long and 6–7 mm wide at the base, erect and very thickly set on the disc, as figured by Tixier-Durivault (1958, fig. 138). The texture of the coenenchym is firm and brittle. The autozooids are distinct, about 2 mm apart on the lobes but rather scarce in the area between the lobes.

The coenenchymal spicules of the lobes are almost barrels, with 4–6 whorls of tubercles; they measure in millimetres: 0·16 × 0·08, 0·2 × 0·082. In the disc cortex are contained tuberculate spindles, measuring in millimetres: 0·12 × 0·02, 0·16 × 0·05, 0·2 × 0·04.

Distribution.—Widespread in the warm Indo-West Pacific area.

Lobophytum crassospiculatum Moser, 1919

(Text-fig. 2; pl. 15, fig. 1)

Lobophytum crassum Marenz. var. *sansibaricum* May, 1900, p. 119, pl. 5, fig. 9 (pars).

Lobophytum crebriplicatum Marenzeller, 1886, p. 362, pl. IX, fig. 7.

Lobophytum crebriplicatum var. *crassospiculatum* Moser, 1919, p. 273, text-fig. 16; Roxas, 1933, p. 363.

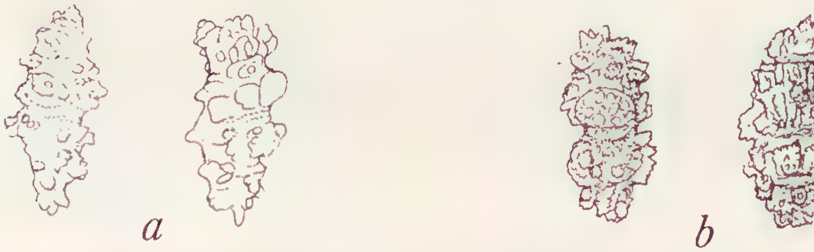
Lobophytum crassospiculatum, Tixier-Durivault, 1958, p. 132, figs. 140, 147 and 148; Tixier-Durivault, 1966, p. 78, fig. 61.

Lobophytum crebriplicatum, Utinomi, 1953, p. 156, text-fig. 4*f–h*, pl. VIII, fig. 7.

Material.—Coll. no. 6. A small colony, 55 mm × 30 mm in extent. East Point, Darwin, on rocks at mid tide level. Very common. Coll. E. C. Pope, 26–X–1965.

Colour in life.—Brownish.

Description.—The columnar stalk is 1–2 cm high, thick, robust and 3 cm across at base. The capitular disc is provided with radially arranged 8 large and small plate-form high lobes, thickly set. The largest lobe measures 23 mm high, 35 mm long and 5–6 mm in thickness. Larger lobes reach the centre of the disc, but smaller ones are set only marginally. High lobes are closed below at the margin of the disc and their tip is plain or secondarily bilobed slightly. Lower lobes are open below at the margin of the disc. The autozooids are large, about 0·2–0·3 mm in diameter and 1·5 mm apart. Between them lie the closely set siphonozooids.



Text-fig. 2.—*Lobophytum crassospiculatum* Moser. *a*, spicules from stalk cortex; *b*, spicules from stalk interior. (All × 110.)

The interior of the stalk contains barrel-shaped spicules with large compound tubercles in more than 4 whorls, up to 0·27 mm long and 0·07 mm wide. The spicules in the stalk cortex are rather less-tuberculate spindles with smaller warts in undifferentiated whorls, as long as 0·2 mm on an average.

Distribution.—Tokara Islands (Utinomi), Philippines (Moser, Roxas), Zanzibar (May, Moser, Tixier-Durivault).

Genus **Sarcophyton** Lesson, 1834 (emend. Marenzeller, 1886)

Sarcophyton moseri Roxas, 1932

(Text-fig. 3)

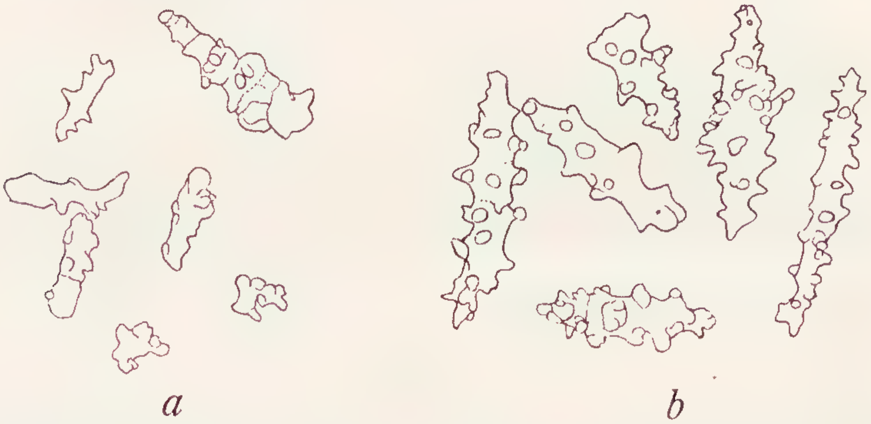
Sarcophyton moseri Roxas, 1932, p. 80, figs 2a–2e; Roxas, 1933, p. 378, pl. 1, fig. 6; Utinomi, 1953, p. 155, text-fig. 3g–3m, pl. 8, fig. 5.

Sarcophytum moseri, Tixier-Durivault, 1946, p. 169; Tixier-Durivault, 1958, p. 14, figs 4 and 10.

Material.—Coll. no. 8. Half of a complete colony. Dudley Point reef, Darwin, in muddy area. Coll. E. C. Pope, 14–X–1965.

Colour in life.—Greenish with fluted margins showing pinkish tint.

Description.—The specimen, light greyish in alcohol, measures 3 cm across at the base of the short stalk, 1·5 cm high at the centre of the disc which is 7 cm across *in situ* and marginally folded. Marginal folds are only slightly projecting over the slightly hollowed upper surface and evenly thin, being 2–3 mm in thickness. They are all simple, undivided into secondaries. The autozooids are few in number and concentrated towards the hollowed centre of the disc. A few of the autozooids are extended in preservation and small in size.



Text-fig. 3.—*Sarcophyton moseri* Roxas. *a,* spicules from stalk cortex; *b,* spicules from stalk interior. (All × 96.)

The spicules of the stalk cortex are tiny rods with 1 or 2 whorls of warts; they measure in millimetres: 0·005 × 0·0017, 0·01 × 0·0026, 0·017 × 0·007, 0·035 × 0·003. The spicules of the stalk interior are small, tuberculate spindles; they measure in millimetres: 0·14 × 0·035, 0·18 × 0·035, 0·26 × 0·035, 0·3 × 0·04, 0·35 × 0·05.

Distribution.—Philippines (Puerto Galera Bay, Mindoro), southern Japan (Nakanosima, Tokara Islands), New Caledonia (Noumea).

Sarcophyton ehrenbergi Marenzeller, 1886

(Pl. 15, fig. 4)

For synonymy and description see: Tixier-Durivault, 1958, p. 16, figs 5 and 12.

Material.—Coll. no. 11. A small colony. Dudley Point, Darwin, in pools in muddy zone. Coll. E. C. Pope, 14–X–1965.

Colour in life.—Greenish.

Description.—The specimen, greyish and brittle in alcohol, is quite mushroom-shaped, only 34 mm high and 35 mm across where the disc is only feebly folded around the margin.

Most of the spicules contained are fairly small slender spindles with few warts, as repeatedly described and figured by Marenzeller (1886), Burchardt (1902), Pratt (1903, 1905), Moser (1919), Roxas (1933) and Tixier-Durivault (1958).

Distribution.—Recorded from various localities in the Red Sea and the Indian and Pacific Oceans.

Sarcophyton glaucum (Quoy and Gaimard, 1833)

(Pl. 15, fig. 3)

For synonymy and description see: Moser, 1919, p. 253, fig. 12; Tixier-Durivault, 1958, p. 61, figs 58, 66–68; Utinomi, 1959, p. 307, fig. 2.

Material.—Coll. no. 7. A small colony. East Point, Darwin, in muddy area at mid tide level. Coll. E. C. Pope, 26–X–1965.

Description.—A single specimen here examined is a light brown-coloured contracted disc, 8 cm × 4 cm in extent, the basal part of the stalk being cut off. The disc is convoluted marginally and hides completely the top of the stalk which is roughly 5 cm × 2·5 cm in extent. The texture is somewhat hard in alcohol.

The autozooids are large, 1–2 mm apart and there are 4–5 distinct siphonozooids between 2 autozooids.

The spicules contained in the interior of the stalk are barrel-shaped spindles with compound warts, 0·2–0·28 mm long. In the cortex of the stalk occur tiny slender tuberculate spindles with compound warts, about 0·003–0·12 mm long.

Distribution.—Widespread in coral reefs of the Indo-West Pacific tropical area.

Sarcophyton trocheliophorum Marenzeller, 1886

(Text-fig. 4; pl. 15, fig. 5)

For description and synonymy see: Marenzeller, 1886, p. 359, pl. IX, figs 5–6. Moser, 1919, p. 246, figs 8–9. Roxas, 1933, p. 379, pl. I, fig. 7. Tixier-Durivault, 1958, p. 75, figs 76, 82 and 83.

Material.—Coll. no. 5. Part of a large colony. East Point, Darwin, on rocks at E.L.W. spring tide. Coll. E. C. Pope, 26–X–1965.

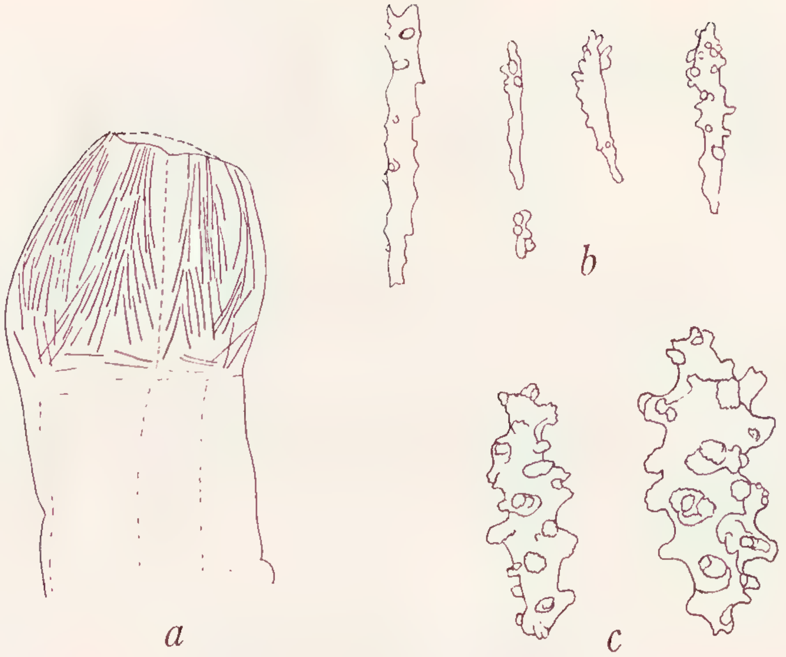
Colour in life.—Flesh-coloured stock with ash-grey polyps.

Description.—The specimen preserved in alcohol is uniformly yellowish brown and rather soft in texture.

The autozooids are much larger than those of the preceding *S. glaucum*. And the siphonozooids are distinct to the naked eye and numerous; there are approximately 5 siphonozooids between 2 autozooids, 2–3 mm apart, on the lateral surface of lobes. On the upper surface of the disc the distance between autozooids becomes much wider, up to 5 mm at contracted state.

The upper surface of the disc is very broad and flat, the margin of the disc forms some downwardly-bent thick folds.

In contrast with a figure made by Tixier-Durivault (1958, fig. 76B, C) based on a young specimen, the spiculation of a well grown autozooid, about 1 mm in diameter, herein figured (text-fig. 4*a*) shows 8 chevroned rows of slender point spicules above a few similar ones in transverse rows. In *S. glaucum*, however, such transverse collarets are lacking (Verseveldt, 1965, p. 32, fig. 1). The introvertible neck zone is devoid of spicules. The coenenchymal spicules of the stalk are mostly roundly-ended, barrel-shaped spindles scattered with very large compound warts irregularly, whereas the cortical spicules of the disc are tiny rods with small simple warts.



Text-fig. 4.—*Sarcophyton trocheliophorum* (Quoy and Gaimard). *a*, distal part of autozooid; *b*, spicules from disc cortex; *c*, spicules from stalk interior. (*a* × 30, *b*–*c* × 96.)

Distribution.—Widespread in the warm Indo-West Pacific area, as far north as Tokara Islands, southern Japan (Utinomi, 1953, p. 155).

Genus **Sinularia** May, 1900

Sinularia polydactyla (Hemprich and Ehrenberg, 1834)

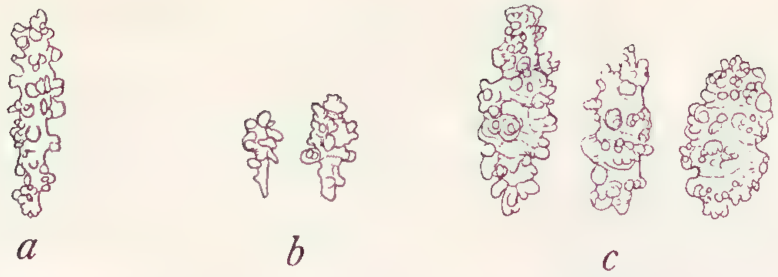
(Text-fig. 5)

For description and synonymy see: Roxas, 1933, p. 353, pl. 2, fig. 7; Tixier-Durivault 1951, p. 50, figs 43, 44, 57–66. And also refer to Utinomi, 1956, p. 227 (Palau); Verseveldt, 1960, p. 240 (Malay Archipelago); Tixier-Durivault, 1966, p. 185, figs 178–180 (Madagascar).

Material.—Coll. no. 4. Half of a large colony. Fannie Bay, Darwin, attached to rocks on mid shore. Coll. A. J. Boase and E. C. Pope, 12–X–1965. Coll. no. 9. Part of a somewhat small colony. Dudley Point, Darwin, in pools in muddy zone. Coll. E. C. Pope, 14–X–1965.

Colour in life.—Olive green.

Description.—Both specimens here examined in alcohol are greyish or white in colour and hard in texture, though brittle. The larger one (Coll. no. 4) has many well-extended digitate branches, 2–4·5 cm long and 1·1–1·5 cm wide at base, like those shown in a photograph from living colonies (cf. Macfadyen, 1936, pl. I, fig. 2), while the smaller one (Coll. no. 9) retains the contracted state of the branches as shown in the same author's photograph (cf. pl. I, figs 1 and 3)—namely, the largest lobe measures only 3·5 cm long and 2 cm wide at base. Each of the lobes are divided into secondary and tertiary branches. It suggests that the external appearance of preserved specimens of such leathery alcyonarians differs greatly, depending upon the time of collecting and of placing in fixatives in the field.



Text-fig. 5.—*Sinularia polydactyla* (Hemprich and Ehrenberg). *a*, spicule from cortex of lobes; *b*, spicules from stalk cortex; *c*, spicules from stalk interior. (All × 96.)

The spiculation of the cortex and interior of both specimens coincides fairly well. The interior of the robust stalk is thickly filled with many stout spindles up to 3 mm long. In the cortex of the stalk are contained small clubs, 0·075–0·175 mm long with a head 0·03–0·07 mm wide.

Distribution.—Widespread in coral reefs of the Red Sea and the tropical Indo-West Pacific.

Genus **Nephthea** Audouin, 1828

Nephthea chabrolii Audouin, 1828

(Pl. 16, fig. 1)

Nephthea chabrolii Audouin, 1828, p. 230 (Explanation for Savigny's "Description de l'Egypte . . .", 1817, pl. 2, figs 51–5; later reproduced by Shann, 1912, pl. LXI, figs 2–5 and pl. LXII, fig. 6).

Nephthya chabrolii, Klunzinger, 1877, p. 33, pl. II, figs. 5*a*-5*d* (Red Sea); Kükenthal, 1896, p. 89 (with varieties *ternatana* and *moluccana*); Kükenthal, 1904, p. 157 (synonymy); Thomson and Russell, 1910, p. 183 (Salomon Reef, East Africa); Thomson and Dean, 1931, p. 83 (Malay Arch.).

Spongodes (*Nephthya*) *chabrolii*, Holm, 1895, p. 25, pl. 2, figs. 1–3.

Nephthea chabrolii, Roxas, 1933, p. 412 (Palawan, Philippines); Utinomi, 1954c, p. 59, fig. 2 (Kii coast, middle Japan); Utinomi, 1956, p. 233 (Palau Is.); Verseveldt, 1966, p. 14, text-figs 6–7, pl. 4, fig. 1 (Java); Tixier-Durivault, 1966, p. 273, figs 256–259 (Nosy Bé, Madagascar).

Material.—Coll. no. 101. Three colonies. East Point, Darwin. Coll. A. J. Boase, late X–1967.

Colour in life.—Pale fleshy-pink grey stock, with ashy-purplish polyps.

Description.—The well preserved specimens show pale yellow in polyparium and ivory white in sterile stem. They measure 6–7 cm long and each one attached together at their bases consists of 2- to 4-times divided flabby main stem, 2·5–4 cm wide at base and covered with a number of cone-shaped catkins on branches. These polyp-bearing catkins are rounded at the tips and variable in size, ranging from 3 mm × 2 mm to 9 mm × 4 mm.

The spiculation has been fully described and figured, especially by Verseveldt (1966) and Tixier-Durivault (1966) in detail, so that it is unnecessary to reiterate their descriptions here.

According to the field note by Miss Pope, this nephtheid represents a major zoning organism at L.W.M. spring tide level.

Distribution.—Widespread in the Red Sea and the warm Indo-West Pacific area as far north as middle Japan (Utinomi, 1954c).

Genus **Stereonephthya** Kükenthal, 1905

Stereonephthya whiteleggi Kükenthal, 1905

(Text-fig. 6; pl. 15, fig. 6)

Spongodes pallida, Whitelegge, 1897, p. 221, pl. XII, figs 7*a–c* (not Holm, 1895).

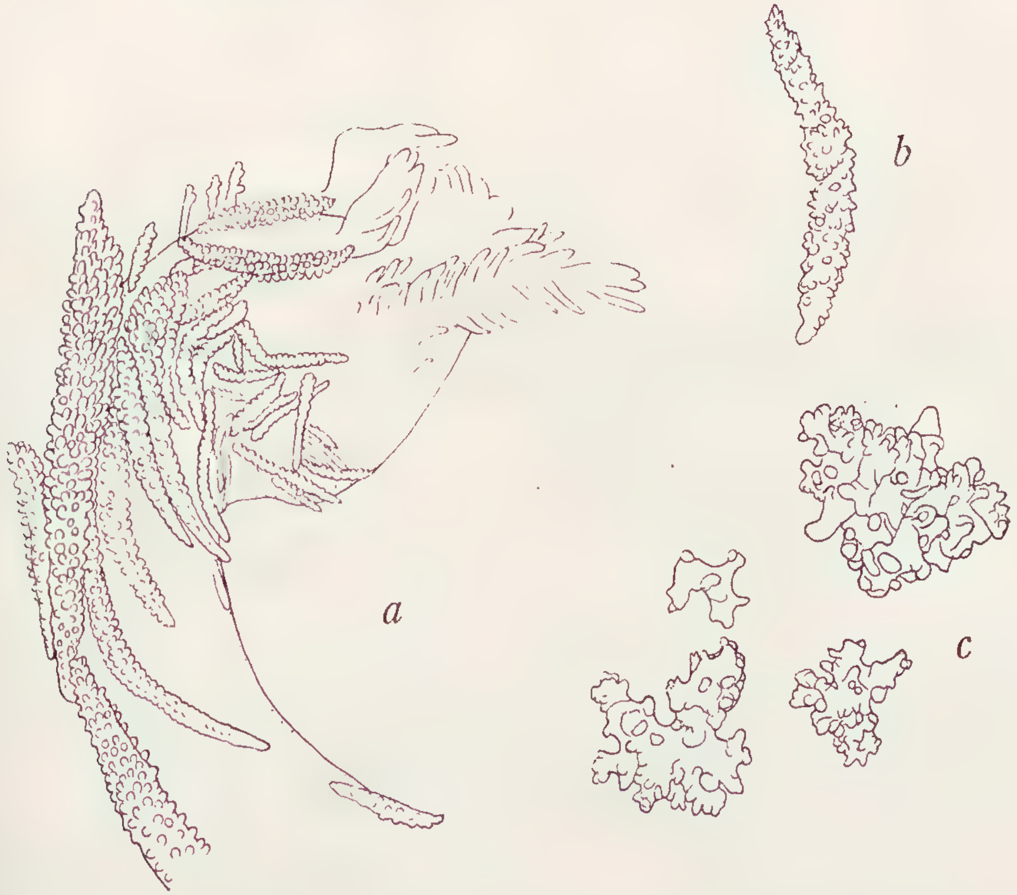
Stereonephthya whiteleggi Kükenthal, 1905, p. 705, fig. L2, pl. 32, fig. 57; Kükenthal, 1910, p. 57, pl. III, fig. 23, text-fig. 29.

Material.—Coll. no. 1. A small colony. Darwin Harbour, attached to screen of power house intake. Coll. E. C. Pope, 22–X–1966.

Colour in life.—Cream-white stock, light purplish towards the base of stalk, as in alcohol.

Description.—The specimen in alcohol is 8 cm long, of which the lower 2·5 cm long belongs to the sterile stalk. According to a label attached to the material, however, this has shrunk to about ¼ of its size in life.

The stalk is flabby and evenly cylindrical with a maximum diameter of 13 mm. At its light-purplish base a few short stolons exist. The main stem is quite white, narrower and more flabby than the lower stalk. It arises 3 narrower side branches, 2–3·5 cm long, obliquely upwards on either side, so that the polyparium is somewhat flattened. The side branches and their short twigs, mostly 3–5 mm long, bear a few cream-coloured, incurved polyps.



Text-fig. 6.—*Stereonephthya whiteleggi* Kükenthal. *a*, zooid; *b*, point spicule; *c*, spicules from stalk cortex. (*a* × 53, *b–c* × 96.)

The polyps, about 5 in group, are small and have rather slender long stalk. The anthocodia is supported dorsally by a few spicules of which the uppermost one slightly projects over the head. The point spicules on lateral sides are rather small and mostly 3-paired; those in the ventral row are much smaller. The ventral side of the polyp stalk mostly lacks spicules.

In the stem cortex small, transparent spindles are arranged mostly transversely. In the stalk cortex irregular-shaped, strongly tuberculate, small spicules are contained. The interior of the stalk and stem apparently lacks spicules.

Distribution.—Hitherto recorded only from Funafuti Atoll, Ellice Islands, 40–70 fms (Whitelegge, 1897), Tapam-Pass (Kükenthal, 1905) and northwest Australia (Kükenthal, 1910).

Stereonephthya costatofulva (Burchardt, 1898)

(Text-fig. 7; pl. 16, fig. 2)

Spongodes costatofulva Burchardt, 1898, p. 440, pl. XXXI, figs 7–7a; pl. XXII, figs 5a–c.

Stereonephthya costatofulva, Kükenthal, 1905, p. 697.

Material.—Coll. no. 2. Two complete colonies. Darwin, attached to base of screens of power house. Coll. E. C. Pope, 22–X–1966. (Shrunk to 1/4 the size in life.)

Coll. no. 106. A small shrunken colony. East Point, Darwin, near L.W.M. spring tide. Coll. A. J. Boase, late X–1967.

Coll. no. 107. A large, heliotrope-coloured colony, attached to supports of wharf. Darwin Harbour, E.L.W.M. spring tide. Coll. A. J. Boase, IX–1967.

Coll. no. 109. A shrunken colony. East Point, Darwin, at E.L.W.M. spring tide. Coll. A. J. Boase, IX–1967.

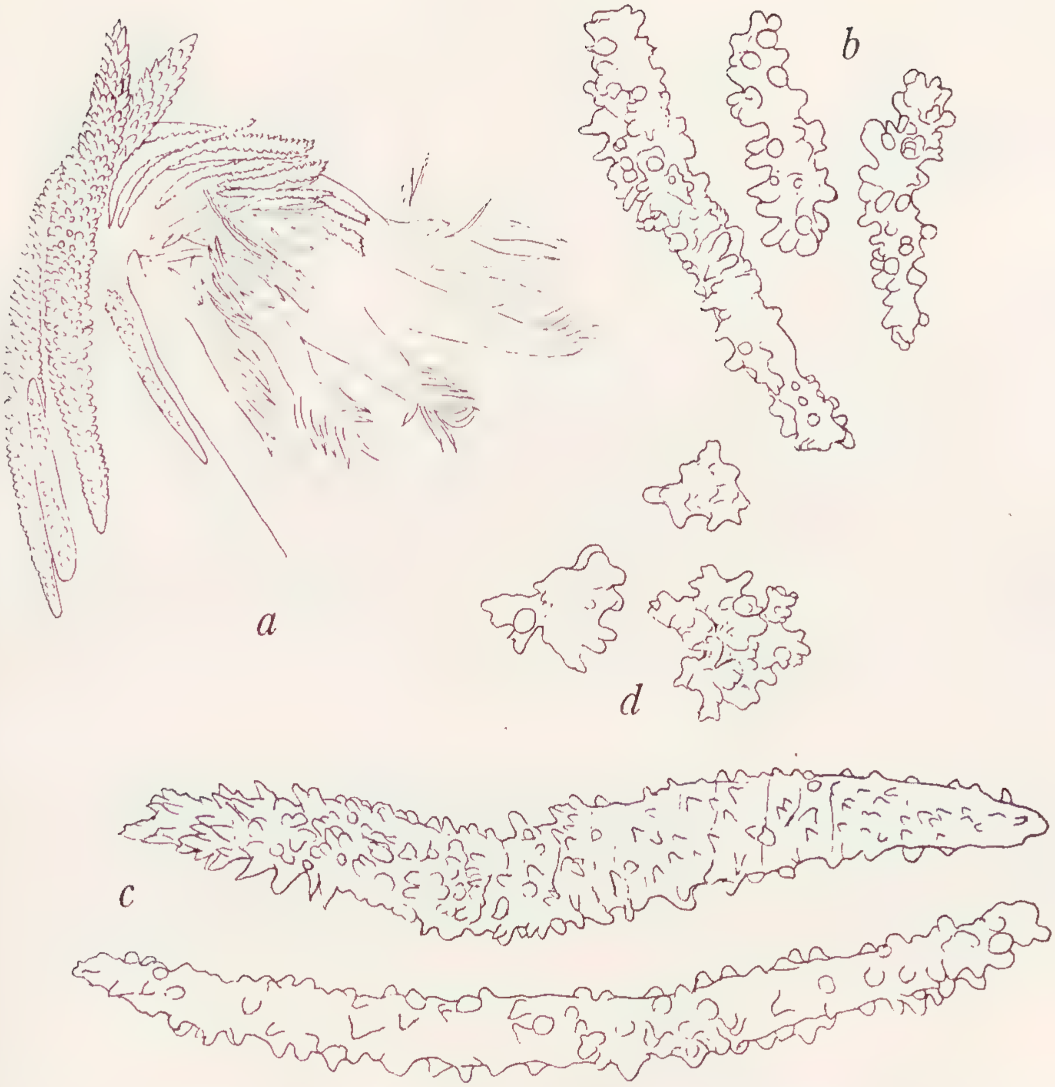
Colour in life.—Largely heliotrope and polyps slightly deeper shade of heliotrope (Coll. no. 107). Burgundy-coloured (Coll. no. 2).

Description.—A number of light or deep purple coloured specimens represented here are certainly referable to *Stereonephthya costatofulva* (Burchardt), recorded only once from the Torres Straits, despite various shade of colouration.

All specimens, either large or small, have a roughly oblong polyparium, flattened in one plane. The sterile stalk is rather evenly cylindrical and lacks stolons at base. The ratio of length between the polyparium and stalk is 3:2. The main stem and branches are uniformly plump and flabby.

The colour in spirit is generally light purple in upper stem and branches, while the stalk is light brown drab. The polyps crowded on branchlets and twigs are much more dark purple (burgundy), often mottled with white tentacles when extended.

The polyp heads are small, campanulate, standing at right or acute angles to the stalks. They measure less than 2 mm in length; the supporting bundle is of the sheathing type, consisting of 7 or 8 robust spicules of which the uppermost 1 or 2 project a little beyond the head. The anthocodial armature is composed of 8 rows of points, each consisting of steeply sloping slender spindles (red or purplish red in transmitted light); dorsal (adaxial) ones are well developed but not distinctly paired, lateral ones distinctly 2-paired and ventral (abaxial) ones are small, 1-paired only. All these point spicules do not project beyond the base of tentacles. In addition, there are one pair of smaller intermediate spicules between points. S. B. spicules are robust and deep red but often translucently white distally. The tentacles are large and adorned with many slender pinnules, but lack spicules.



Text-fig. 7.—*Stereonephthya costatofulva* (Burchardt). *a*, zooid; *b*, spicules from branch cortex; *c*, S. B. spicule (above) and spicule from upper stem (below); *d*, spicules from stalk cortex. (*a* × 33, *b–d* × 96.)

The branch cortex is covered with pink-coloured irregular bodies with irregular warts, 0·08–0·12 mm across. The canal-walls of the stem and stalk lack spicules.

Distribution.—Type locality: Thursday Island, Torres Straits.

Stereonephthya costatocyanea (Burchardt, 1898)

(Text-fig. 8; pl. 16, fig. 3)

Spongodes costatocyanea Burchardt, 1898, p. 441, pl. XXXI, fig. 8; pl. XXXII, figs 6a–e.

Stereonephthya costatocyanea, Kükenthal, 1905, p. 698.

Material.—Coll. no. 104. One colony, 11 cm long. East Point, Darwin, E.L.W.M. spring tide. Coll. A. J. Boase, late X–1967.

Coll. no. 105. One colony, 14 cm long. East Point, Darwin, E.L.W.M. spring tide. Coll. A. J. Boase, late X–1967.

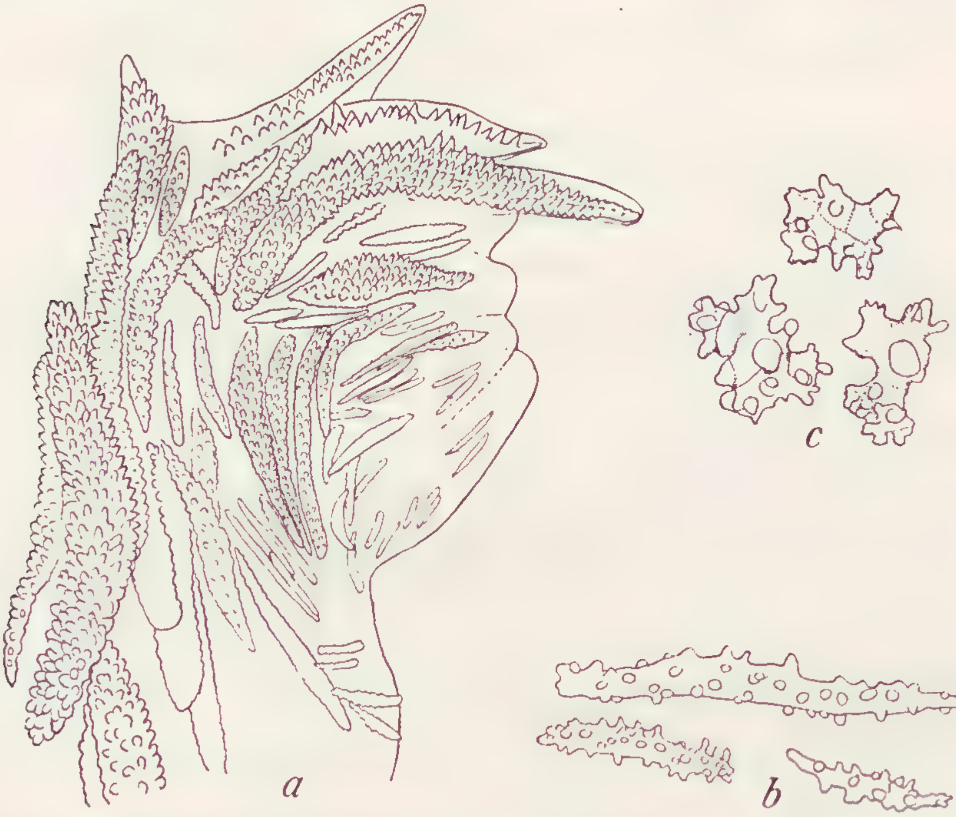
Coll. no. 110. A small shrunk colony, 6 cm long. Dudley Point, Darwin, E.L.W.M. spring tide. Coll. A. J. Boase, IX–1967.

Colour in life.—Open polyps orange. Branch cortex and buried polyps are dark purple. Upper stem dull purple, fading towards the stalk, where it is generally dull brown, becoming reddish brown towards the base.

This colouration, mentioned on a label attached to the material, does not so much differ from that of alcohol-preserved specimens.

Description.—In the well-developed colonies (Coll. nos. 104 and 105), the main stem is uniformly plump, cylindrical, as wide as 3 cm and erect in life. Most of the short branches are given off rather horizontally around the lower part of the stem. Longer branches are given off in the upper part of the stem and directing upwards. Polyp-bearing twigs are arranged in close-set groups on these branches and solitarily on the lower stem. So the polyparium, occupying the upper half of the stem, may be described as "arborescent" in form, not so distinctly flattened as in the preceding *costatofulva.* In a smaller colony (Coll. no. 110), however, the upper stem divides bush-like at their ends into slender branches, branchlets and twigs, the latter bearing at their ends zooids in small groups. The polyparium is thus distinctly demarcated from the sterile stalk and the colouration of the cortex and polyps of the polyparium is much darker.

The external surface of the stem and branches, devoid of polyp-bearing twigs, is delicately wrinkled transversely, leathery in texture and contains irregularly small slender spindles, purple in colour, measuring in millimetres: 0·23 × 0·04, 0·25 × 0·035, 0·3 × 0·03. The cortex of the sterile stalk contains red-purple coloured, star-shaped spicules arranging irregularly; they measure in millimetres: 0·023, 0·07 and 0·1 across. The interior of the stem and branches is almost vacant, and paper-like canal-walls are devoid of spicules.



Text-fig. 8.—*Stereonephthya costatocyanea* (Burchardt). *a*, zooid; *b*, spicules from branch cortex; *c*, spicules from stalk cortex. (*a* × 53, *b–c* × 96.)

The polyp-head is cone-shaped, standing at obtuse angle to the short, robust stalk; it measures about 0·23 mm long (projecting point spicules excluded), about 0·8 mm long (point spicules included) and 0·7–0·8 mm wide. The polyp-stalk is 0·35 mm long on the ventral side just below the head, and 0·9 mm long on the dorsal side (S. B. spicules included).

The anthocodial armature is stronger towards the dorsal side and weaker towards the ventral side. The uppermost point spicules on the dorsal side and dorsal one of the dorso-lateral rows are conspicuously strong, hockey-stick-like in shape, and project far beyond the oral margin, forming "crest-like projections" apically together with the S. B. spicules at the lower level. The point spicules of the lateral rows and ventro-lateral rows are smaller, and those on the ventral row are much smaller and less tuberculate. They measure in millimetres for a specimen figured here: S. B. spicules (robust spindles), 0·9 × 0·18, 1·23 × 0·14; uppermost hockey-stick-like spicules in dorsal row, 0·3 × 0·09; uppermost hockey-stick-like spicules in dorso-lateral row, 0·7 × 0·09; uppermost spicules in ventro-lateral and ventral rows, 0·17 × 0·035.

Besides, there are one or two pairs of smaller intermediate spicules between points. The anthocodial grade and formula of spiculation for the genus *Dendronephthya* may be applied, too, as follows: IV = 1P + 2p + 0Cr + (1 — 2)M + very strong S. B.

Details of colouration in anthocodial and cortical spicules in transmitted light are:

S. B. spicules: orange (in peripheral layer), colourless (in deeper layer).

Projecting point spicules: orange (lower half) and yellow (distal part).

Non-projecting point spicules and intermediates: reddish orange.

Accessory spicules near S. B.: orange to yellow.

Tentacle spicules: almost colourless ("green" according to Burchardt; "greenish yellow" according to Kükenthal).

Distribution.—Type locality: Thursday Island, Torres Straits.

Stereonephthya longicaulis Kükenthal, 1911

(Text-fig. 9; pl. 16, fig. 4)

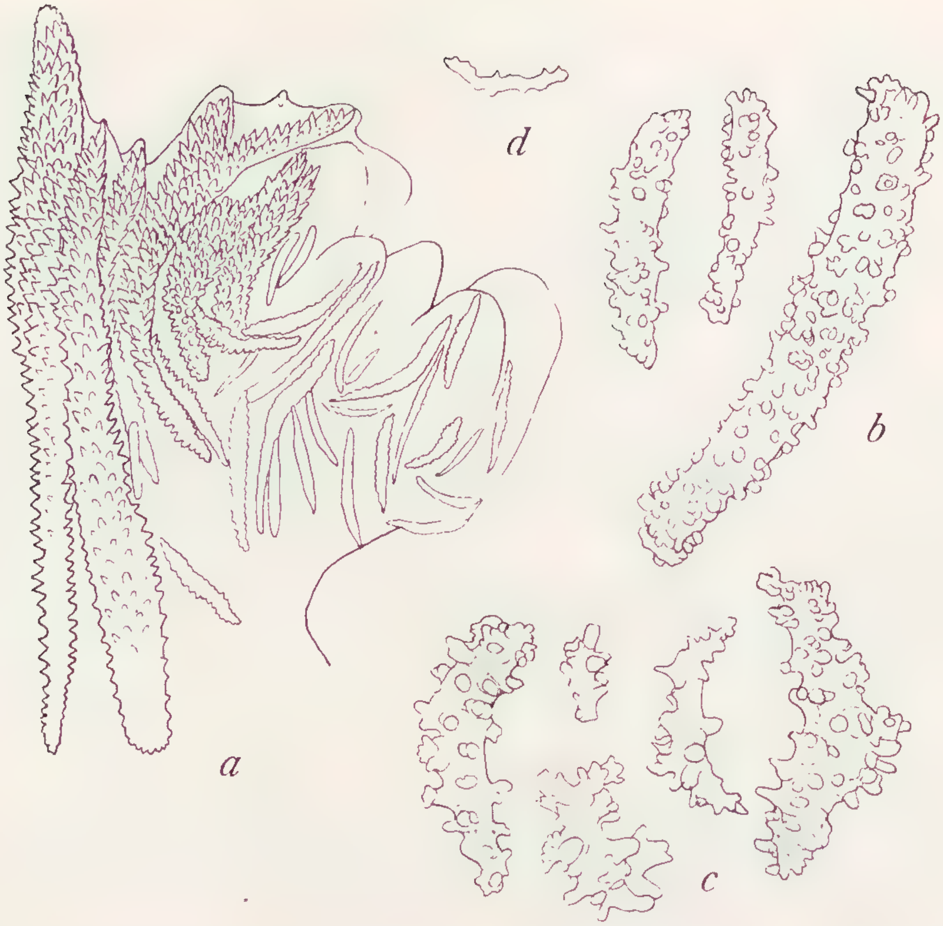
Stereonephthya longicaulis Kükenthal, 1911, p. 324, figs 38–40, pl. XXI, fig. 12.

Material.—Coll. no. 103. A single colony, wrapped by a greenish mottled compound ascidian (*Leptoclinum virens ?*) round the basal part. East Point, Darwin, near E.L.W.M. spring tide level. Coll. A. J. Boase, late X–1967.

Colour in life.—Deep claret-coloured stock with lemon-yellow to orange polyps.

Description.—The specimen, 85 mm in total length, is flabby and uniformly cylindrical. Its lower part, approximately 4 cm long and 1·5 cm wide, is largely sterile and may be called the stalk. The upper part of the stock is secondarily divided into two large branches, both about 3 cm long and 1 cm wide, in addition 5 shorter branches (2–3 cm long, 1 cm wide) and a number of polyp-bearing branchlets are given off at different levels; these branches and branchlets are blunt-tipped and grouped together somewhat in a flattened plane. Also, a number of polyps, each one 2–3 in small transverse lappets and a few polyp-bearing twigs, 3–5 mm long, are scattered all over the stock.

The outer surface of the nude stock is uniformly claret (purplish red) and weakly wrinkled transversely. The interior of the stock seems to be vacant, only supported by quite white, thin canal-walls.



Text-fig. 9.—*Stereonephthya longicaulis* Kukenthal. *a*, zooid; *b*, spicules from branch cortex; *c*, spicules from stalk cortex; *d*, spicule from canal-walls, scarcely found. (*a* × 66, *b*–*d* × 96.)

Each polyp stands upright in small lappets transversely arranged. On the bare stem there are mostly 1–3 zooids for a lappet, supported dorsad by a few stout spicules down *in situ*, although variably directed around the twigs. The zooids themselves are small, ca. 0·6 mm high, 0·5 mm wide, and the anthocodia stands at obtuse angle to the very short, thick stalk, lying in parallel with the supporting bundle of which the tip slightly projects beyond the head proper.

The anthocodial armature consists of eight double rows of steeply converging spicules, each in 3–5 pairs; dorsal point spicules are much larger and strongly spinose than those of the lateral sides, while those on the ventral side are smaller and fewer, though not wholly suppressed. Between the point spicules there are one pair of intermediate spicules on the lateral sides. The ventral side of the polyp stalk is wholly nude. Eight tentacles are bent inward and cover the oral opening of the cup, apparently lacking spicules. The supporting bundle is of the sheathing type, thick and composed of 5–6 large, stout spindles, only up to 2 mm in length.

On the branch cortex, blunt-ended, slender spindles with small warts, red-coloured, are arranged longitudinally; they measure in millimetres: 0·18 × 0·1, 0·2 × 0·05, 0·26 × 0·035, 0·4 × 0·04, 0·9 × 0·1. On the stalk cortex, red-coloured, kneed spindles or irregular bodies covered with high warts are irregularly scattered; they measure in millimetres: 0·18 × 0·1, 0·2 × 0·05, 0·23 × 0·09. The canal-walls are mostly devoid of spicules, although very tiny, bright-red, rods (0·17 × 0·003) occur very scarcely. S. B. spicules and accessory spicules are deep-red, while the point spicules are mostly lemon-yellow or often orangish. The point spicules on lateral sides measure in millimetres: 0·17 × 0·026 to 0·5 × 0·035.

Distribution.—Type locality: Aru Islands in the Arafura Sea (Kükenthal, 1911).

Stereonephthya armata Kükenthal, 1910

(Text-fig. 10; pl. 16, fig. 5)

Stereonephthya armata Kükenthal, 1910, p. 58, figs 30–31 and pl. IV, fig. 26; Broch, 1916, p. 8 (not figured).

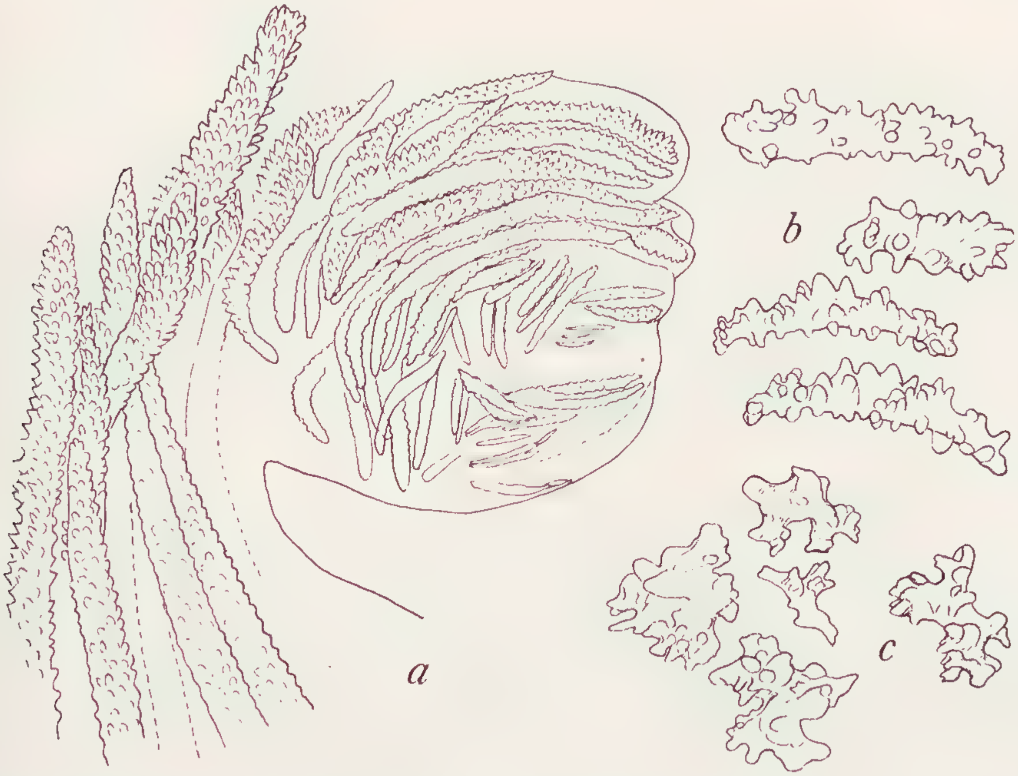
Material.—Coll. no. 108. A small shrunk colony, 8 cm long. Darwin Harbour, on the base of supports of wharf, at E.L.W.M. spring tide. Coll. A. J. Boase, X–1967.

Colour in life.—Pale flesh-coloured stock, tending to mauve basalwards.

Description.—The specimen attached to a barnacle (*Balanus amaryllis* Darwin), preserved in alcohol, consists of the uniformly cylindrical sterile stalk, ca. 4 cm long and 1·5 cm in basal diameter, and the flattened polyparium, occupying the upper half of the main stock. The lower half is strongly wrinkled longitudinally, flabby and mauve-coloured (light dull-purple).

The upper polyparium consists of a main stem and three side branches arising from each side; all are flattened in one plane, flabby in texture, with light yellowish-brown cortex transversely wrinkled and dull-yellowish zooids arranged in small lappets.

The zooids are very small, about 1 mm high (up to the tip of the supporting bundle). The polyp-head is 0·6 mm wide, 0·7–0·8 mm long, and stands at right angle to the short, thick stalk (0·6 mm long on the ventral side below the head and 0·6 mm wide at base). The supporting bundle is thick, of the sheathing type and composed of about twelve robust spicules in a triangle peripherally; it does not project beyond the tip of the head; uppermost ones are mostly blunt-ended, colourless, and measure in millimetres up to 1·0 × 0·07.



Text-fig. 10.—*Stereonephthya armata* Kukenthal. *a*, zooid; *b*, spicules from branch cortex; *c*, spicules from stalk cortex. (*a* × 53, *b–c* × 96.)

The anthocodial armature is well developed towards the dorsal side where the point spicules are large and thickly set, not forming any ordinary paired row. On the lateral sides, the point spicules are also strong but show indistinct arrangement *en chevron;* each point is composed of three pairs of colourless, curved, long spindles (0·35 × 0·035, 0·43 × 0·035 in mm), not projecting beyond the base of tentacles. On the ventral side the point spicules are only one-paired and small (0·17 × 0·01 mm). These point rows are generally widely separated on the ventro-lateral sides, but often 2–3 smaller intermediates occur between them. The ventral side of the polyp-stalk is quite nude.

On the branch cortex, colourless, blunt-ended, short, warty spindles (0·18 × 0·035, 0·2 × 0·05, 0·43 × 0·07 in mm) are closely packed, roughly transversely. On the sterile stalk cortex, pale purple, star-shaped spicules with large conical warts (0·05, 0·07, 0·08, 0·1 mm across) are irregularly arranged. The canal-walls are apparently devoid of spicules, despite Kükenthal's mentioning and figures.

Distribution.—Sharks Bay, West Australia (type locality, Kükenthal, 1910), and 42–45 miles W.S.W. off Cape Jaubert, 66–72 feet, northwest Australia (Broch, 1916).

Stereonephthya bellissima Thomson and Dean, 1931

(Text-fig. 11; pl. 16, fig. 6)

Stereonephthya bellissima Thomson and Dean, 1931, p. 143, pl. VII, figs. 2–5; Roxas, 1933, p. 460, pl. 2, fig. 5.

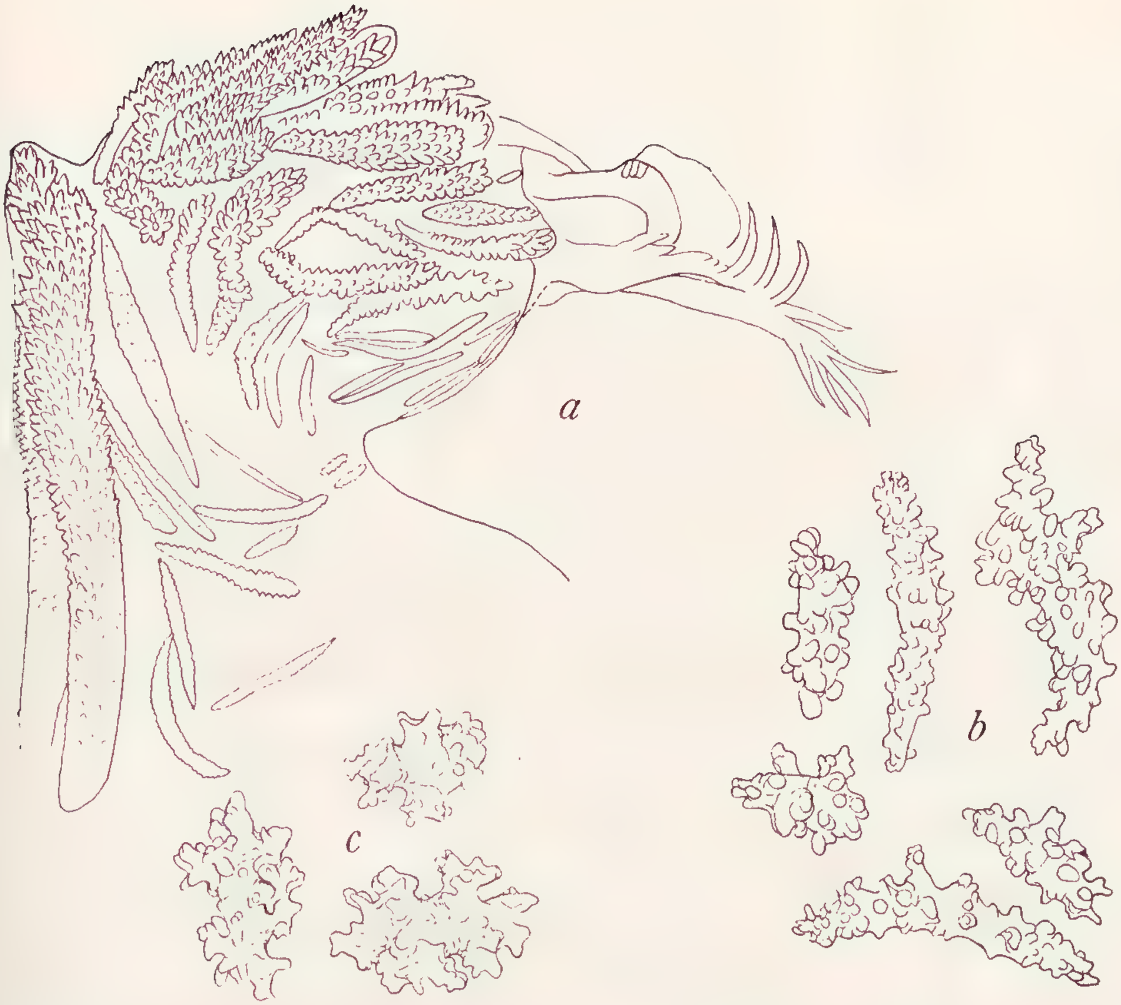
Material.—Coll. no. 111. A beautiful complete colony. Dudley Point reef, Darwin, at E.L.W.M. spring tides. Coll. A. J. Boase, 1967.

Colour in life.—Stock dirty pink at base, through grey to purple near branches. Polyps brick red.

Description.—The sterile stalk, lacking stolons, is very short, about 1·5 cm long and as wide; its cortex is leathery and dull purple in colour. From this short stalk four upright stems (2·5 cm, 3 cm, 3·5 cm, 5 cm and 5·5 cm in length respectively) arise at the tip. Each stem is flaccid proximally and gives off a number of shorter digitate branches (1–5 cm long), bearing numerous polyps on all sides, where they are more thickly arranged together than on the main stems, giving the side branches remarkable rigidity in contrast to the flabby main stems. On the main stems proper, however, a few polyps are arranged only in small transverse lappets. These polyp-bearing side branches are roundly tipped and uniformly 3–5 mm in diameter, variably in accordance with their own length. Thus, the polyparium may be called "shrubby in appearance".

Polyps are on the average 1·2 mm long and 0·6 mm wide, making a very acute angle with the stalk, usually short, less than 1 mm long, so the head is truly not campanulate.

The anthocodial armature consists of five double rows only, the dorsal three rows being strong (0·4–0·5 mm long and 0·05 mm wide) and not distinctly paired; on the lateral sides point spicules are 3- or 4-paired and 0·35 × 0·05 mm in size. On the ventral three rows point spicules are 2-paired and much smaller, non-tuberculate, only 0·2 × 0·03 mm. All these point spicules are bright red in transmitted light; larger ones may be called "clavate" but never opaque. Intermediates are not found. The tentacles have small white discoid spicules which lie transversely in the contracted condition; pinnules are slender and translucent. The supporting bundle is of the sheathing type; usually two outer spicules are larger, about 1·2 mm long and 0·1 mm wide, and project beyond the head for about 0·3 mm; peripheral spicules are deep-red wholly, while deeper ones are lighter or colourless.



Text-fig. 11.—*Stereonephthya bellissima* Thomson and Dean. *a*, zooid; *b*, spicules from upper cortex; *c*, spicules from stalk cortex. (*a* × 53, *b–c* × 96.)

On the cortex of branches and upper stem, small spindles with high conical warts and derivatives are irregularly packed; they measure in millimetres: 0·17 × 0·05, 0·2 × 0·09, 0·35 × 0·07, 0·7 × 0·07; of these smaller forms are mostly bright red in transmitted light, while larger ones are mostly orangish. On the cortex of the sterile stalk, which externally looks purplish-brown, red-coloured, highly tuberculate star-shaped bodies, mostly 0·15 mm across, are densely packed together; these spicules may be derivatives of smaller spindles distributed on the upper stem. The canal-walls lack spicules at all, although Roxas says there occur very scarcely pointed spindles or rods 0·42 mm long.

Distribution.—Unrecorded *Siboga* station in the Malay Archipelago (Thomson and Dean, 1931) and Puerto Galera Bay, Mindoro Island (Roxas, 1933).

Remarks.—The anthocodial armature of this beautifully red stereonephthyid, originally illustrated in colour painting only by an artist (Miss Alice M. Davidson), not by the authors themselves (cf. Thomson and Dean, 1930, pl. VII, figs 2–5), seems to me to be very unsatisfactory, as her rough sketches omitted giving details of the most important zooidal characters peculiar to *Stereonephthya* for differentiating from the related *Dendronephthya*. Also her coloured illustrations of polyp armature appear somewhat different in detail from Roxas's and mine, but this may be negligible, depending in part on either slight colour variation or artistic abridgement.

Genus **Dendronephthya** Kükenthal, 1905

Subgenus **Morchellana** Gray, 1862 (*pro generis*)

Dendronephthya (**Morchellana**) **spinosa** (Gray, 1862)

(Text-fig. 12; pl. 16, fig. 7)

Spoggodes spinosa Gray, 1862, p. 27, pl. IV, figs 5–7; Gray, 1869, p. 128.

Spongodes spinosa var. Ridley, 1884, p. 332.

Spongodes spinosa Gray: Wright and Studer, 1889, p. 197.

Dendronephthya spinosa (Gray): Kükenthal, 1905, p. 641 (no new locality!).

Morchellana spinosa (Gray): Tixier-Durivault and Prevorsek, 1962, p. 63 (no new locality!).

Dendronephthya Michaelseni Kükenthal, 1910, p. 54, text-fig. 24, pl. III, fig. 17, *syn. nov.*

Dendronephthya Michaelseni var. *laevis* Kükenthal, 1910, p. 55, text-fig. 25, pl. III, fig. 18, *syn. nov.*

Dendronephthya Michaelseni Kükenthal: Broch, 1916, p. 7 (not figured).

Non *Spongodes spinosa* Gray: Studer, 1878, p. 636 (= *Dendronephthya studeri* (Ridley, 1884)).

Material.—Coll. no. 102. A single small shrunk colony. East Point, Darwin, near L.W.M. spring tides, attached in crevice among boulders. Coll. A. J. Boase, X–1967.

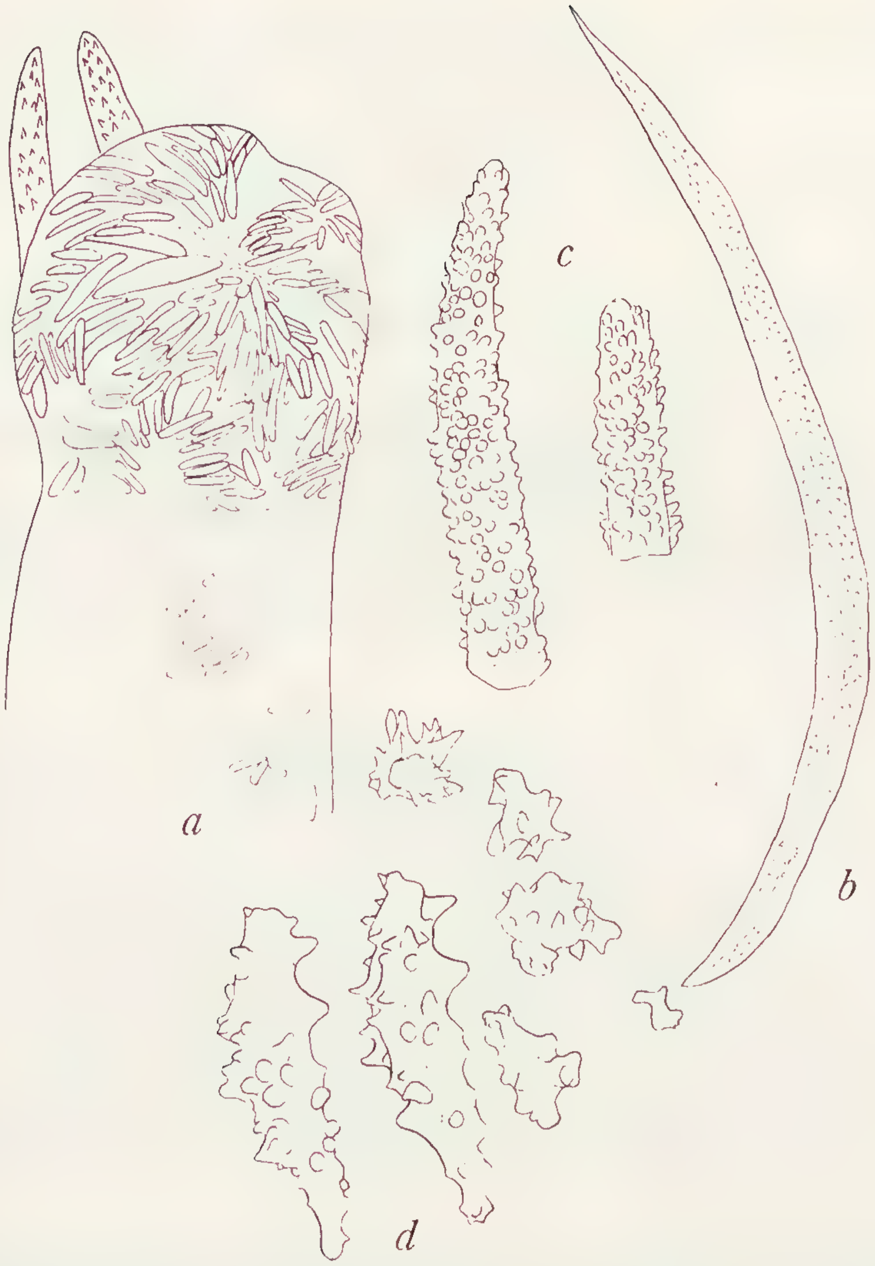
Colour in life.—Dark red (crimson) with white short stock and light prominent spikes projecting over the surface.

Description.—The single specimen here examined is small for the genus and about 2 cm high, with a transversely elongated oval polyparium (20 mm × 35 mm as viewed from top). The present specimen preserved in alcohol is thus strongly depressed obliquely and much shrunken, but when alive it may be forming a roundish spinose mass, as Gray originally notes.

The stalk almost hidden under the lowest foliaceous collar of the umbellate polyparium is pure white against the dark red polyparium, and very short and thick, as measuring about 13 mm long and 15 mm in basal diameter. Its surface is strongly wrinkled longitudinally and terminates to a number of dirty white, paper-slip-like stolons, encircling the base of attachment.

The upper stem, which is about 1 cm long in contracted condition, divides dichotomously into a number of short, thick (ca. 5 mm) secondary branches and then gives rise to thick (ca. 2 mm) branchlets which widen distally to bear the polyps. The distal branchlets are closely arranged into compact umbels, in which the polyps reach to the same level; these umbels are closely pressed together, forming hemispherical masses with a uniform outline. The lowest branches of the polyparium are foliaceous and form together a complete collar, hanging downwards all over the short stalk.

The cortex of branches and branchlets is protected firmly by close-set dark-red, robust spicules longitudinally or transversely arranged; these cortical spicules are often partly concentrated and upheaved at their ends over the surface to form hump-like projections here and there. In consequence of this compact structure, the stem and branches almost entirely hidden from the exterior are rough in appearance.



Text-fig. 12.—*Dendronephthya* (*Morchellana*) *spinosa* (Gray). *a*, zooid, viewed from ventral side, somewhat upward; *b*, spiky projecting spine of supporting bundle, 6 mm long; *c*, part of spicules from cortex of upper stem; *d*, spicules from stalk cortex. (*a* × 66, *b* × 20, *c*–*d* × 96.)

The polyp-head is very small, upward-directing and protected dorsally by one or two, opaque-white, very strong spicules up to 6 mm long; these spike-like spicules are more than 7 times as long as the polyp-head intact. The anthocodial armature belongs to Grade II of Sheriffs' formula (1922), as figured herein.

Formula II = (6 – 8)p + 0Cr + (0 – 1)M + very strong S. B.

Details of these spicules and their measurements in millimetres are as follows:

Upper cortex—dark red or orange, long spindles covered with round warts of similar size, bluntly ended. 0·14 × 0·35, 0·2 × 0·035, 0·26 × 0·05, 0·28 × 0·043, 0·6 × 0·09.

Stalk and stolon cortex—translucent colourless, small spindles or irregular forms covered with round or conical warts. (Spindle form) 0·19 × 0·05, 0·35 × 0·1, 0·45 × 0·12, 0·5 × 0·1. (Irregular form) 0·09, 0·12, 0·17, 0·2, 0·26 (across).

Canal-walls—antler-like flat bodies rarely occurred—0·088 (across).

Point spicules—many red, small rods, mostly 0·1 mm long, becoming larger distalwards.

S. B. spicules—one or two prominently projecting, curved spindles covered with dot-like minute warts, sharply ended, up to 4 mm long and opaque-white throughout.

Ventral side of polyp-stalk mostly nude but a few red small rods, as long as 0·1 mm, occur near the base, arranged transversely.

Distribution.—Previously recorded from New Guinea (Gray, 1862); Port Denison near Bowen, Queensland (Ridley, 1884); Torres Straits (Wright and Studer, 1889); Barrow Island and Port Hedland, northwest Australia (Kükenthal, 1910 as *Dend. michaelseni*); 45 miles W.S.W. off Cape Jaubert, northwest Australia, 66–80 ft. (Broch, 1916 as *Dend. michaelseni*).

Remarks.—Kükenthal (1905) in his revision of the family Nephthyidae (= Nephtheidae) established a new genus, *Dendronephthya*, to contain three groups (Glomeratae, Divalicatae and Umbellatae), and further subdivided the last Umbellatae into 10 subgroups according to the polypary appearance. He denoted the species having spherical polyparium as the "*spinosa*-group" in which *D. spinosa* (Gray) and *D. pumilio* (Studer) are included, although it is probable that he did not examine himself the specimens referable to *D. spinosa*. Afterwards, he (1910) described *Dend. michaelseni* n. sp. together with its variety *laevis* from northwestern Australian coasts. It is indeed strange that he did not recognize its close affinity with Gray's *spinosa* previously known from the neighbouring waters, although he mentioned its close affinity with *Dend. bremirama* (Burchardt) in his "*florida*-group" and *Dend. macrospina* (Wright and Studer) (inserta sedis). In their latest review of *Morchellana* (= Kükenthal's Umbellatae), Tixier-Durivault and Prevorsek (1962) included *Dend. spinosa* within the *spinosa*-group following Kükenthal's system, but regret to say they omitted (or overlooked) the name *michaelseni* and its var. *laevis*.

As mentioned above, there is a striking resemblance between the present specimen and Gray's coloured figure of *Spoggodes spinosa* and also with Kükenthal's excellent photographs of *Dend. michaelseni*, and especially *Dend. michaelseni* var. *laevis*, in the appearance of the polyparium and the anthocodial armature as regards the polyp armature, this species is much more like that of *D. villosa* Kükenthal in Kükenthal's "*dendrophyta*-group" than that of D. *pumilio* (Studer) in his "*spinosa*-group". The former *villosa* belongs to Sheriffs' grade I, whereas the latter *pumilio* belongs to grade IV.

In conclusion, *Dendronephthya michaelseni* and its variety *laevis* seem to be identical with Gray's "*Spoggodes spinosa*", and therefore both Kükenthal's junior names should be suppressed as synonyms. Supposedly the type specimen deposited in the West Australian Museum at Perth, on which the description of *D. michaelseni* Kükenthal was based, may have been dried or else was long preserved at that time. In comparison with it, *D. michaelseni* var. *laevis* Kükenthal was described and figured, based on the relatively fresh specimens collected during the Hamburger Southwest Australian Expedition in 1905, as deduced from a comparison of both photographs given in Kükenthal's paper (1910, pl. III, figs 17 and 18) and the present fresh material (pl. 16, fig. 7).

COENOTHECARIA

Genus **Heliopora** Blainville, 1834

Heliopora coerulea (Pallas, 1766)

(Pl. 16, fig. 8)

For description and literature see: May, 1900, p. 174; Eguchi, 1948, p. 362, pl. 60, figs 3, 4 and 6.

Material.—Portion of a large colony taken on reef flat at Cape Don, Cobourg Peninsula, near L.W.M. neap tide, in pool. Coll. E. C. Pope 17–X–1965.

Ecological notes.—Covered large areas of the intertidal reefs at Cape Don, Cobourg Peninsula, 200 miles N.E. of Darwin. Colour of surface greeny-brown but skeleton blue when branches were broken off.

Distribution.—Widespread in tropical Indo-Pacific coral reefs.

REFERENCES (Selected)

Audouin, V. (1828). Explication sommaire des planches de l'Egypte et de la Syrie, publicees par Jules-Cesar Savigny, dans: Description de l'Egypte, **23**. Paris. [Actinies, polypes tubifères, polypes corticaux: 225–231.]

Broch, Hj. (1916). Results of Dr E. Mjöbergs Swedish Scientific Expeditions to Australia 1910–1913. XI. Alcyonarien. *Kungl. Vetenskapsakad. Handl.*, **52** (11): 1–48, pls 1–4.

Burchardt, E. (1898). Alcyonaceen von Thursday Island (Torres-Strasse) und von Amboina. I. Alcyonaceen von Thursday Island. *Denkschr. med.-nat. Ges. Jena*, **5**: 431–442, pls XXXI–XXXII.

——— (1902). Alcyonaceen von Thursday Island (Torres-Strasse) und von Amboina. II. Alcyonaceen von Amboina. *Denkschr. med.-nat. Ges. Jena*, **8**: 653–682, pls LIV-LVII; also reproduced in Semon's, *Zool. Forschungen*, **5**.

Dana, James D. (1846–1849). United States Exploring Expedition during the years 1838–1842 under the command of Charles Wilkes, U.S.N. Vol. **VII.** Zoophytes. Philadelphia. [Alcyonaria: 586–684; Atlas (1849), pls 57–60.]

Dean, L. M. I. (1932). Alcyonaria. *Res. Sci. Voyage Indes Orient Neerl.* (*Mem. Mus. roy. Hist. nat. Belg.*, N. S.), **2** (11): 1–24.

Eguchi, M. (1948). Fossil Helioporidae from Japan and the South Sea Islands. *Jour. Paleontol.*, **22** (3): 362–364, pl. 60.

Ehrenberg, C. G. (1834). Die Corallenthiere des rothen Meeres, physiologisch untersucht und systematisch verzeichnet. Berlin. 158 pp.

Gray, J. E. (1862). Description of some new species of *Spoggodes* and of a new allied genus (*Morchellana*) in the collection of the British Museum. *Proc. zool. Soc. Lond.*, **1862**: 27–31, pl. IV.

——— (1869). Notes on the fleshy Alcyonoid corals (*Alcyonium*, Linn., or Zoophytaria carnosa). *Ann. and Mag. nat. Hist.*, ser. 4, **3**: 117–131.

Hickson, S. J. (1883). The structure and relations of *Tubipora*. *Q. J. micr. Sci.*, **92**: 556–577, pls 39–40.

Holm, O. (1895). Beitrage zur Kenntniss der Alcyonidengattung *Spongodes* Lesson. *Zool. Jahrb., Abt. Syst.*, **8** (1): 8–57, pls 2–3.

Klunzinger, C. B. (1877). Die Korallthiere des rothen Meeres. Erster Theil: Die Alcyonarien und Malacodermen. Berlin. pp. i–vii, 20–94, pls I–V.

Kolonko, K. (1926). Beitrage zu einer Revision der Alcyonarien. Die Gattung *Sinularia*. *Mitt. zool. Mus. Berlin,* **12:** 291–334, pls I–IV.

Kukenthal, W. (1896). Alcyonaceen von Ternate. Nephthyidae und Siphonogorgiidae Kölliker. *Abhandl. Senck. Naturf. Ges.,* **23** (1): 81–144, pls V–VIII.

——— (1903). Versuch einer Revision der Alcyonarien. II. Die Familie der Nephthyiden. 1. Theil. *Zool. Jahrb., Abt. Syst.,* 19 (1): 99–172, pls V–VIII.

——— (1905). Versuch einer Revision der Alcyonarien. II. Die Familie der Nephthyiden. 2. Teil. Die Gattungen *Dendronephthya* n. g. und *Stereonephthya* n. g. *Zool. Jahrb., Abt. Syst.,* 21 (5/6): 503–726, pls 26–32.

——— (1910). Alcyonaria. 1. Teil. In: Michaelsen, W. & R. Hartmeyer (*ed.*), *Fauna Sudwest-Australiens,* **3** (1): 1–108, pls I–IV.

——— (1911). Alcyonarien von den Aru- und Kei-Inseln nach den Sammlungen von Dr H. Merton. *Abhandl. Senck. Naturf. Ges.,* **33** (4): 305–346, pls XIX–XXIII.

Macfadyen, L. M. I. (1936). Alcyonaria (Stolonifera, Alcyonacea, Telestacea and Gorgonacea). *Sci. Rep. Great Barrier Reef Exped.,* **5** (2): 4–71, pls I–V.

Marenzeller, E. von (1886). Ueber die *Sarcophytum* benannten Alcyoniiden. *Zool. Jahrb.,* **1** (2): 341–368, pl. IX.

May, W. (1900). Beitrage zur Systematik und Chorologie der Alcyonaceen. *Jena. Zeit. Naturw.,* **33** (N. F. 26) (for 1899): 1–180, pls I–V.

Moser, J. (1919). Beitrage zu einer Revision der Alcyonarien. I. Die Gattungen *Sarcophyton* Lesson und *Lobophytum* Marenzeller. *Mitt. zool. Mus. Berlin,* **9** (2): 219–293, pls V–VI.

Pope, E. C. (1967). The shore reefs of Darwin. *Australian nat. Hist.,* **15** (9): 278–284.

Pratt, E. M. (1903). The Alcyonaria of the Maldives. Part II. The genera *Sarcophytum, Lobophytum, Sclerophytum,* and *Alcyonium.* In: Gardiner, J. S. (*ed.*), *Fauna and geography of the Maldive and Laccadive Archipelagoes,* **2** (1): 504–539, pls XXVIII–XXXI.

——— (1905). Report on some Alcyoniidae collected by Professor Herdman, at Ceylon, in 1902. In: Herdman, W.A. (*ed.*), *Rep. Pearl Oyster Fisheries of the Gulf of Manaar,* part III, Suppl. Rep. **19:** 247–268, pls I–III.

Quoy, J. R. C. and J. P. Gaimard (1833). Voyage decouvertes de l'Astrolabe execute par ordre du Roi, pendant les annees 1826–1827–1828–1829, sous le commandement de M. J. Dumont d'Urville. Zoologie. **IV.** Zoophytes. 389 pp., 26 pls J. Tastu, Paris. [Zoophytaires (= Octocorallia): 255–284, pls 21–23.]

Ridley, S. O. (1882). Contributions to the knowledge of the Alcyonaria with descriptions of new species from the Indian Ocean and the Bay of Bengal. Ann. and Mag. nat. Hist., ser. 5, **9:** 184–193.

——— (1884). Alcyonaria. In: Report on the zoological collections made in the Indo-Pacific Ocean during the voyage of H.M.S. *Alert* 1881–2, pp. 327–365, 666–668, pls XXXVI–XXXVIII. London.

——— (1889). Report on the alcyoniid and gorgoniid Alcyonaria of the Mergui Archipelago, collected for the Trustees of the Indian Museum, Calcutta, by Dr John Anderson, F.R.S. *Jour. Linn. Soc. Lond., Zool.,* **21:** 223–247, pls XVII–XVIII.

Roule, L. (1908). Alcyonaires d'Amboine. *Rev. Suisse Zool.,* **16:** 161–194, pls 6–8.

Roxas, H. A. (1933). Philippine Alcyonaria, II. The families Alcyoniidae and Nephthyidae. *Philipp. J. Sci.,* **50** (4): 345–470, pls 1–5.

Savigny, J. C. (1817). Description de l'Egypte ou Recueil des observations et des recherches qui ont ete faites en Egypte pendant l'expedition de l'armee francaise. Histoire naturelle. Tome Deuxieme. Partie **1** (Invertebree). 105 pls [Octocorallia: Tome I, Partie 4, Planche 1–3.] Paris.

Shann, E. W. (1912). Observations on some Alcyonaria from Singapore, with a brief discussion on the classification of the family Nephthyidae. *Proc. zool. Soc. Lond.,* **1912** (34): 505–527, pls LXI–LXIII.

Sheriffs, W. R. (1922). Evolution within the genus *Dendronephthya* (*Spongodes*) (Alcyonaria), with descriptions of a number of species. Proc. zool. Soc. Lond., **1922** (3): 33–77, pls I–III.

Studer, Th. (1878). Uebersicht der Anthozoa Alcyonaria, welche wahrend der Reise S. M. Gazelle in die Erde gesammelt wurden. *Monatsber. Kon. Preuss. Akad. Wiss. Berlin,* 1878: 631–688, pls I–V.

——— (1895). Alcyonarien aus dem Sammlung des Naturhistorischen Museums in Lubeck. *Mitt. geogr. Ges. Naturh. Mus. Lubeck,* ser. 2, **7–8:** 103–128, pls I–VI.

Thomson, J. A. and L. M. I. Dean (1931). The Alcyonacea of the Siboga Expedition with an addendum to the Gorgonacea. *Siboga-Expeditie,* monogr. **13d:** 1–227, pls I–XXVIII.

Thomson, J. A. and W. D. Henderson (1905). Report on the Alcyonaria collected by Professor Herdman, at Ceylon, in 1902. In: Herdman, W. A. (*ed.*), *Rep. Pearl Oyster Fisheries of the Gulf of Manaar,* part III, Suppl. Rep. **20:** 269–328, pls I–VI.

Thomson, J. A. and D. L. Makinnon (1910). Alcyonarians collected on the Percy Sladen Trust Expedition by Mr J. Stanley Gardiner, Part 2. The Stolonifera, Alcyonacea, Pseudaxonia and Stelechotokea. *Trans. Linn. Soc. Lond.,* ser. 2 (Zool.), **13** (8): 168–211, pls 6–14.

——— (1911). Scientific results of the Trawling Expedition of H.M.C.S. *Thetis* off the coast of New South Wales, in February and March, 1898. Part 13. Alcyonaria. *Mem. Aust. Mus.,* **4:** 661–695, pls LXI–LXXXII.

Thomson, J. A. & J. J. Simpson (with W. D. Henderson for *Dendronephthya*). (1909.) An account of the Alcyonarians collected by the Royal Indian Marine Survey ship *Investigator* in the Indian Ocean. II. The Alcyonarians of the littoral area. Indian Museum, Calcutta. xviii + 319 pp., 9 pls.

Thorpe, L. (1928). Alcyonaria of the Abrolhos Islands, western Australia. *J. Linn. Soc. Lond., Zool.,* **36** (247): 479–529, pls 30–34.

Tixier-Durivault, A. (1951). Revision de la famille des Alcyoniidae le genre *Sinularia* May, 1898. *Mem Inst. roy. Sci. nat. Belg.,* ser. 2, **40:** 5–146.

——— (1958). Revision de la famille des Alcyoniidae: Les genres *Sarcophytum* et *Lobophytum. Zool. Verhandl.,* **36:** 1–180.

——— (1966). Octocoralliaires. *Faune de Madagascar,* **21:** 1–456. Paris.

Tixier-Durivault, A. & M. Prevorsek (1962). Le genre *Morchellana* (Alcyonaria, Nephtheidae). *Spolia zool Mus. Hauniensis,* **19:** 1–239.

Utinomi, H. (1952). *Dendronephtyha* of Japan, I. *Dendronephthya* collected chiefly along the coast of Kii Peninsula. *Publ. Seto mar. biol. Lab.,* **2** (2): 161–212, pls IX–XI.

——— (1953). Invertebrate fauna of the intertidal zone of the Tokara Islands. VI. Alcyonaria. *Publ. Seto mar. biol. Lab.,* **3** (2): 149–160, pl. VIII.

——— (1954a). *Dendronephthya* of Japan, II. New species and new records from Kii region. *Publ. Seto mar. biol. Lab.,* **3** (3): 319–338, pls XXXIX–XL.

——— (1954b). Some alcyoniid octocorals from Kii coast, middle Japan. *Publ. Seto mar. biol. Lab.,* **4** (1): 43–55, pl. I.

——— (1954c). Some nephtheid octocorals from Kii coast, middle Japan. *Publ. Seto mar. biol. Lab.,* **4** (1): 57–66, pl. II.

——— (1956). On some alcyonarians from the west Pacific Islands (Palau, Ponape and Bonins). *Publ. Seto mar. biol. Lab.,* **5** (2): 221–242.

——— (1959). Fleshy alcyonarians from southern Formosa. *Publ. Seto mar. biol. Lab.,* **7** (3): 303–312.

Verseveldt, J. (1960). Biological results of the Snelius Expedition. XX. Octocorallia from the Malay Archipelago (Part I). *Temminckia,* **10:** 209–251, pl. VII.

——— (1965). Israel South Red Sea Expedition, 1962. Reports no. 14. Report on the Octocorallia of the Israel South Red Sea Expedition 1962, with notes on other collections from the Red Sea. *Red Sea Fish. Res. Sta. Haifa, Bull.* **40:** 28–48, pls I–III.

——— (1966). Biological results of the Snelius Expedition. XXII. Octocorallia from the Malay Archipelago (Part II). *Zool. Verhand.,* **80:** 1–109, pls 1–16.

Whitelegge, Th. (1897). The Alcyonaria of Funafuti. Part I. *Mem. Aust. Mus.,* **3:** 211–225 pls X–XII.

Wright, E. P. (1869). Notes on the animal of the organ-pipe coral (*Tubipora musica*). *Ann. Mag. nat. Hist.*, ser. 4, **3**: 377–383, pl. 23.

Wright, E. P. and Th. Studer (1889). Report on the Alcyonaria collected by H.M.S. *Challenger* during the years 1873–1876. *Rep. Sci. Res. Voy. "Challenger", Zoology*, **31** (1). London. lxxii + 314 pp., 43 pls.

EXPLANATION OF PLATE 15

Fig. 1. *Lobophytum crassospiculatum* Moser. Coll. no. 6. × 1·1.

Fig. 2. *Lobophytum pauciflorum* (Hemprich and Ehrenberg). Coll. no. 3. Natural size.

Fig. 3. *Sarcophyton glaucum* (Quoy and Gaimard). Coll. no. 7. Appr. natural size.

Fig. 4. *Sarcophyton ehrenbergi* Marenzeller. Coll. no. 11. Natural size.

Fig. 5. *Sarcophyton trocheliophorum* Marenzeller. Coll. no. 5. Natural size.

Fig. 6. *Stereonephthya whiteleggi* Kukenthal. Coll. no. 1. × 1·1.

(All photos: Ch. Araga.)

EXPLANATION OF PLATE 16

Fig. 1. *Nephthea chabrolii* Audouin. Coll. no. 101. Half natural size.

Fig. 2. *Stereonephthya costatofulva* (Burchardt). Coll. no. 2. × 2/3.

Fig. 3. *Stereonephthya costatocyanea* (Burchardt). Coll. no. 104. A little less than natural size.

Fig. 4. *Stereonephthya longicaulis* Kukenthal. Coll. no. 103. A little less than natural size.

Fig. 5. *Stereonephthya armata* Kukenthal. Coll. no. 108. × 2/3.

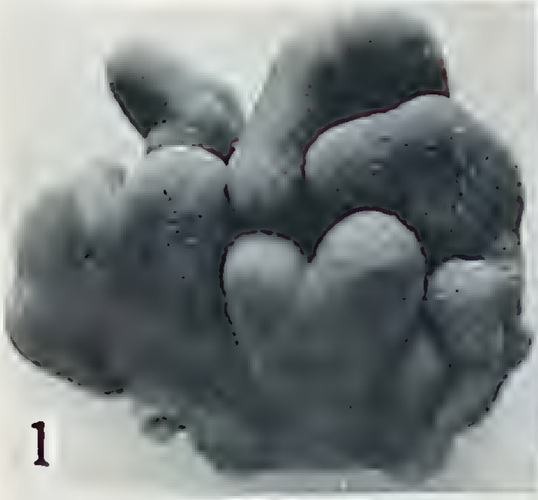
Fig. 6. *Stereonephthya bellissima* Thomson and Dean. Coll. no. 111. A little less than natural size.

Fig. 7. *Dendronephthya* (*Morchellana*) *spinosa* (Gray). Coll. no. 102. Approx. × 1·3.

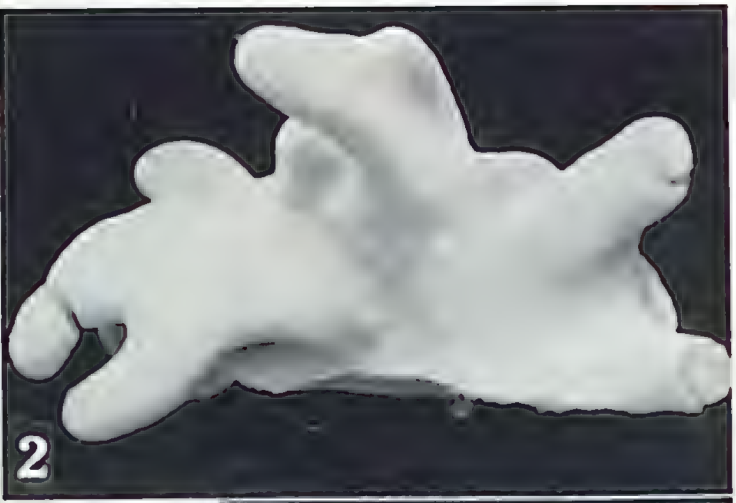
Fig. 8. *Heliopora coerulea* (Pallus). Coll. no. G. 13708. Photo: Miss E. C. Pope at Cape Don reef.

(All photos except Fig. 8: Ch. Araga.)

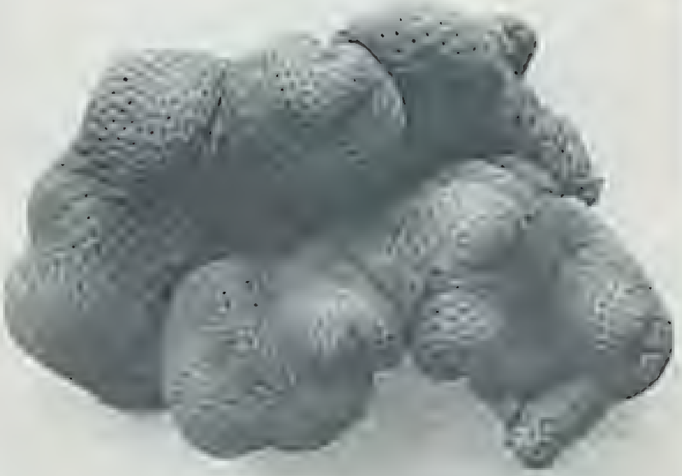
15164 2.71 V. C. N. BLIGHT, GOVERNMENT PRINTER



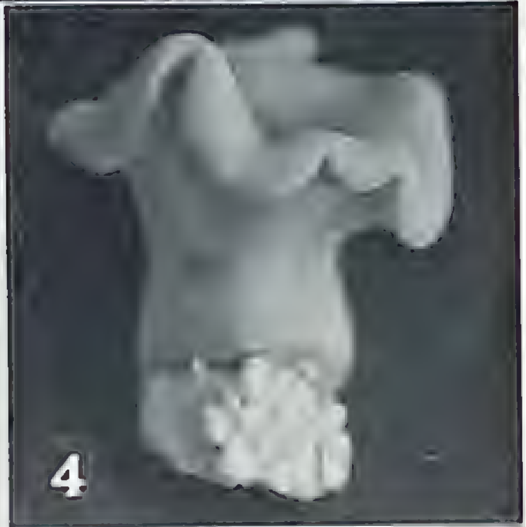
1



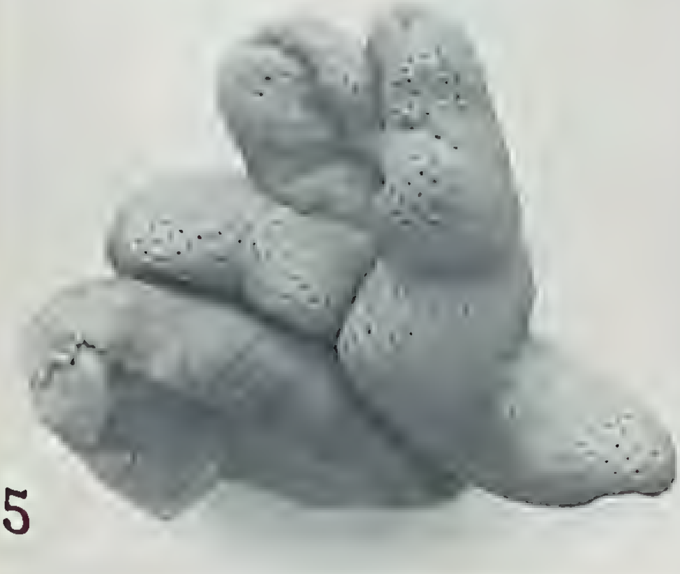
2



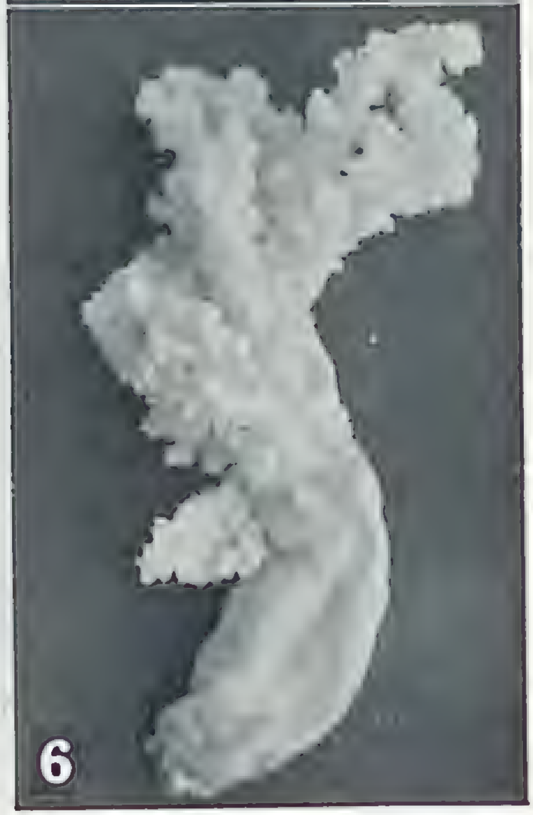
3



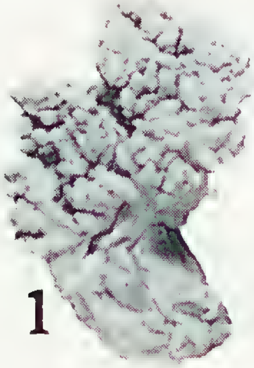
4

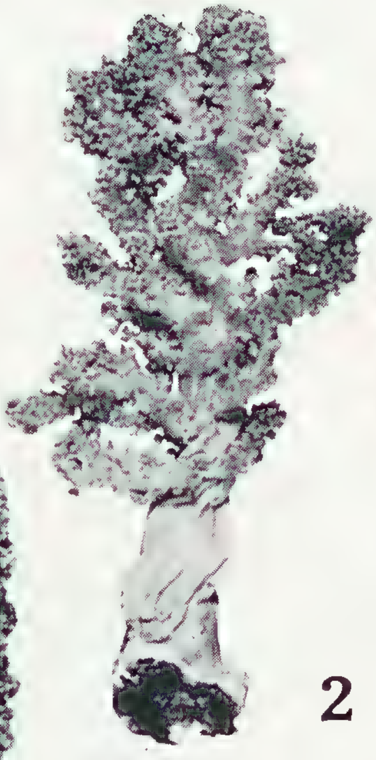


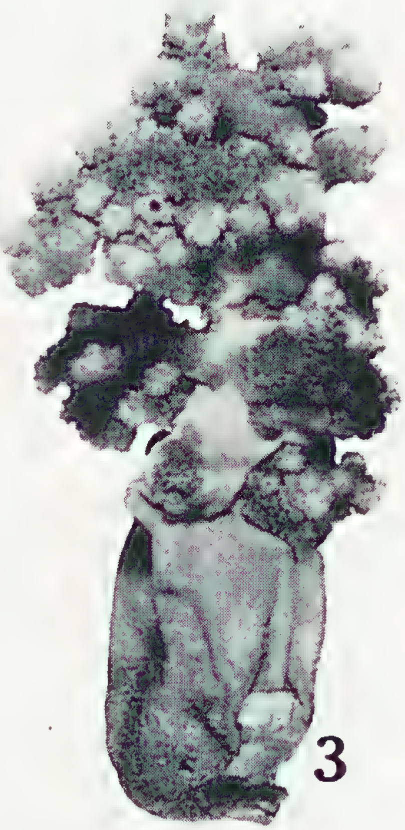
5

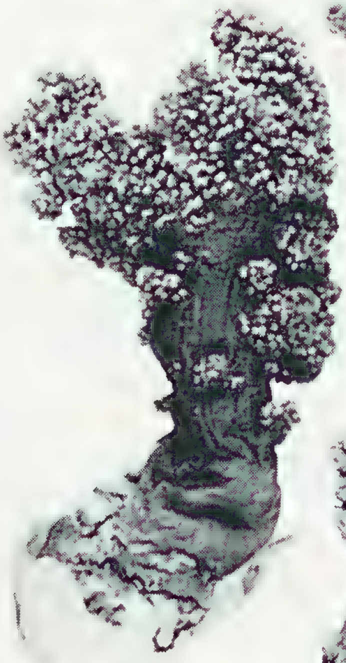


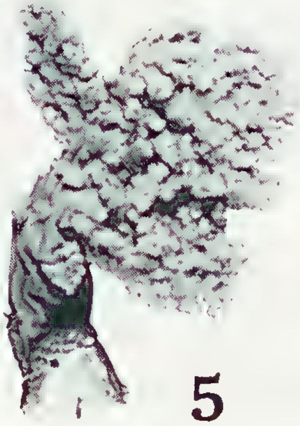
6

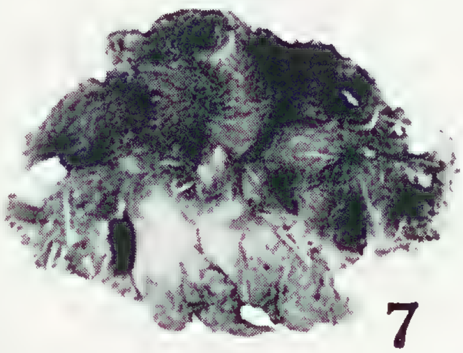

1

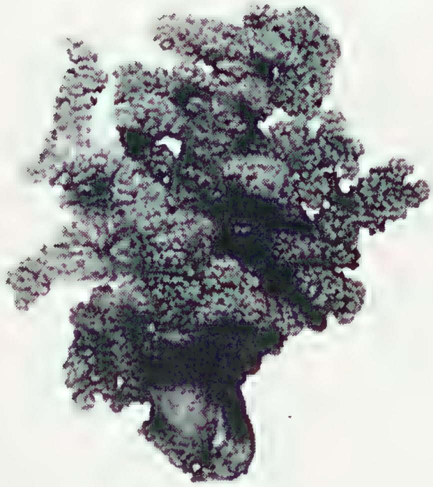

2

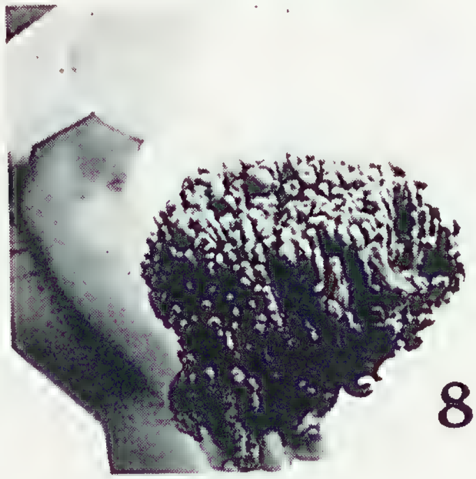

3


4


5


7


6


8

A NEW SPECIES OF *KELLERIA* (COPEPODA: CYCLOPOIDA) FROM BRACKISH WATER IN VICTORIA

By I. A. E. BAYLY

Department of Zoology, Monash University, Clayton, Victoria

Figures 1 and 2 Manuscript received, 20th February, 1969

I. INTRODUCTION

Gurney (1927), while erecting the genus *Kelleria* for the accommodation of two newly discovered species of cyclopoid copepods from the Suez Canal, *K. regalis* Gurney and *K. purpurocincta* Gurney, also suggested the transfer of two previously described species, *Pseudanthessius propinquus* T. Scott (1895) and *P. pectinatus* A. Scott (1909), into this new genus. A similar generic transfer was proposed by Nicholls (1944) for yet another species of *Pseudanthessius—P. fucicolus* T. Scott (1912). In view of the subsequent description of three additional species by Sewell (1949), and that of a fourth by Krishnaswamy (1952), the genus *Kelleria* now contains, in order of description, the following nine species: *K. propinqua* (T. Scott), *K. pectinata* (A. Scott), *K. fucicola* (T. Scott), *K. regalis* Gurney, *K. purpurocincta* Gurney, *K. andamanensis* Sewell, *K. camortensis* Sewell, *K. gurneyi* Sewell, and *K. rubimaculata* Krishnaswamy.

In the course of recent investigations into the brackish water zooplankton of the Gippsland Lakes, Victoria, a species of *Kelleria* has come to hand which corresponds with none of the above species and is here described as new.

II. DESCRIPTION OF SPECIES

Family **LICHOMOLGIDAE** Kossmann

Subfamily **LICHOMOLGINAE** Gurney

Genus **Kelleria** Gurney

It may be noted that neither of the two originally included nominal species were designated or indicated as the type species and so far no subsequent designation has been made. *K. regalis*, being the more fully described and figured of these two, and also having position precedence, would seem to be the logical choice for such a designation. However, since this paper is not of a revisionary nature, formal designation to this effect will be avoided.

Kelleria australiensis sp. nov.

Figs 1A–1P, 2

Specimens Examined. Lake King near Boxes Creek, 30 ♀, 15 ♂ (unlimited material available), coll. C. R. Campbell, 26.i.1968. In addition small numbers were examined from several other collections made at various places within the Gippsland Lake Complex (Lake Victoria and Lake King) by G. H. Arnott.

Type Materials. Holotype ♀, allotype ♂, paratypes 5 ♀, 5 ♂; Australian Museum Reg Nos. P. 16694–6. Holotype, allotype, and some paratypes stained, dissected and mounted on microslides. Type locality: Lake King, Victoria.

Ecological Data. The collection which contained the greatest abundance of the species (Lake King near Boxes Creek) was taken from water with a salinity of 29·6$^{0}/_{00}$, and a temperature of 25.5°C. This was a contaminated collection containing a considerable number of *Parcanassa burchardi* (Gastropoda), several *Zostera* leaves, a fair amount of *Bachelotia* and *Giffordia* (Phaeophyta), and some bottom sediment. The net had obviously brushed through weed and touched the bottom. Consideration of all catches containing it, together with accompanying salinity data, showed that the range of salinity tolerance was at least 27.8–32.1$^{0}/_{00}$.

Description of Female

Size.—Length to end of furcal rami 1.23 mm (mean of ten specimens).

General body proportions (fig. 1A).—Metasome about 1.65 times as long as maximum width (viewed dorsally), and about 1.5 times as long as urosome excluding furcal setae; antennules not reaching posterior margin of first metasomal segment when extended posteriorly; furcal rami about 2.5 times as long as maximum width.

Pre-maxillary appendages.—Antennules 7-segmented, antennae 4-segmented and terminating in two claws and four setae (details of segmentation and armature of these two appendages shown in figures 1B and 1C); mandible (fig. 1D) with about 18 projections along convex margin, ranging in size from long finger-like outgrowths proximally through short rounded teeth to minute serrations distally, terminating in spine-like structure with fine secondary hair-like processes, cluster of about eight spines present on concave or inner margin; maxillule (fig. 1E) small, unsegmented, terminating in three spines (one with secondary processes) with basal thickening and with blunt spur half-way along concave side.

Maxilla (figs. 1F–1H).—Two-segmented, distal segment with total of seven spines and one seta, most proximal spine (that on anterior edge) differentiated from distal row and denticulated along both margins (most proximal and most distal denticles along proximal edge of spine larger than remainder), distal row including four large and two small spines, one or both of latter sometimes obscured depending on orientation so that total of only five or six (fig. 1F) may be apparent (with critical examination, however, total of seven almost invariable).

Maxilliped (fig. 1J).—Three-segmented; middle segment with two large spines on anterior edge, proximal spine about 0.6 times as long as distal spine, with secondary hairs on both sides but row on proximal edge more restricted than that on distal edge, distal spine with secondary hairs along proximal half of proximal edge; distal segment about three times as long as maximum width, with total of four setae, two on anterior edge, one (the longest) terminal, and one on posterior edge.

Legs 1–4.—Structure of legs 1, 2, and 4 shown in figs 1L, 1M, and 1N, respectively; seta and spine formulae as follows:

	Endopodite	Exopodite
P. 1	1.1.420	0.1.422
P. 2	1.2.321	0.1.522
P. 3	1.2.221	0.1.522
P. 4	120 (or 1.020)	0.1.521

Endopodite leg 4 usually 1-segmented, but sometimes with fold or weak line of segmentation coinciding with point of insertion of seta on inner edge giving apparent 2-segmented condition; innermost of two terminal spines of this endopodite sometimes with secondary spine present as anomaly on inner edge.

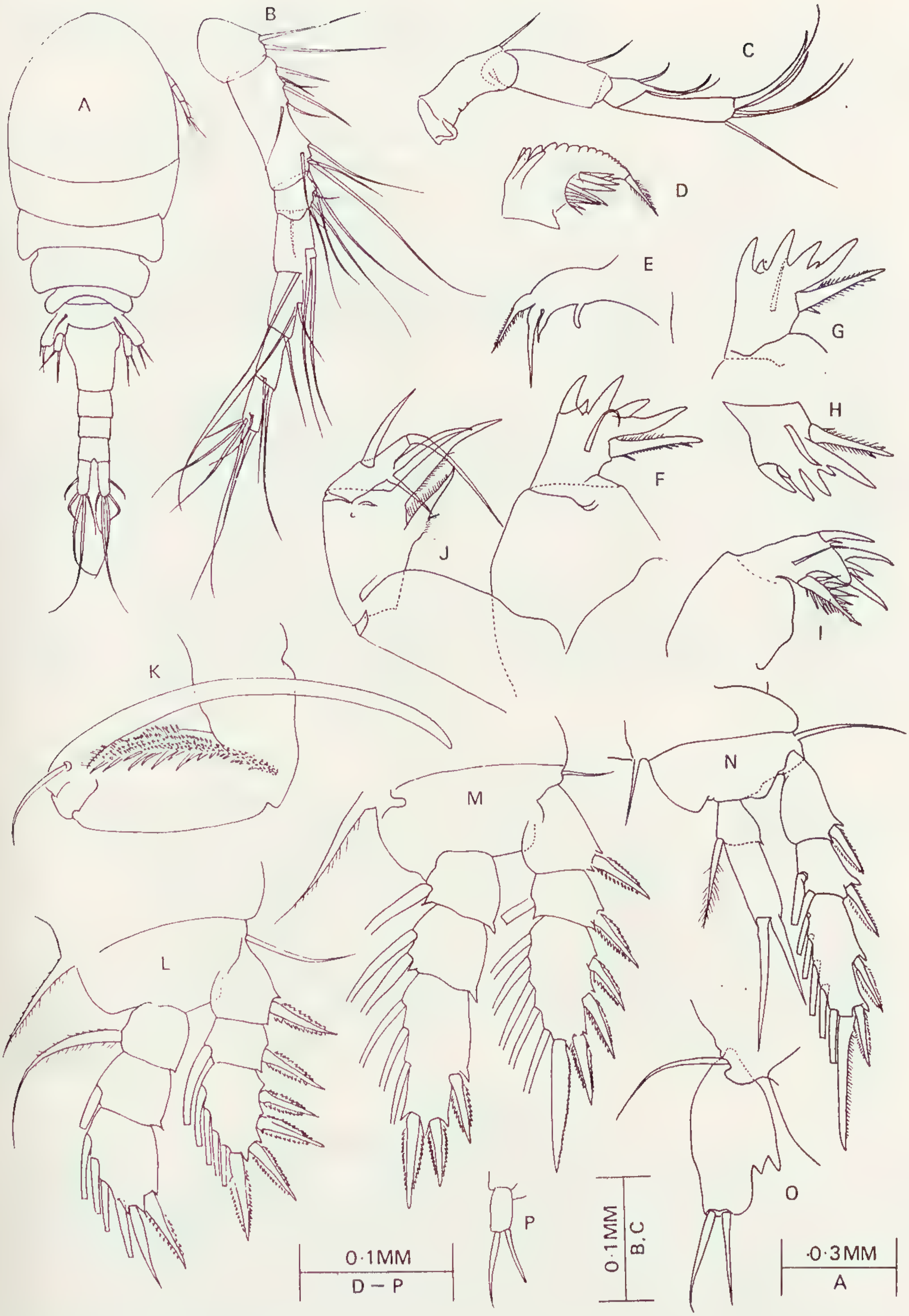


Figure 1.—*Kelleria australiensis* sp. nov. A, dorsal aspect of ♀; B, antennule (♀); C, antenna (♀); D, mandible (♀); E, maxillule (♀); F–H, ♀ maxillae; I, ♂ maxilla; J, ♀ maxilliped (in natural relationship to F); K, ♂ maxilliped; L, leg 1 (♀); M, leg 2 (♀); N, leg 4 (♀); O, ♀ leg 5; P, ♂ leg 5

Legs 5 (fig. 10).—One-segmented, maximum length almost twice maximum width, with two lobes present about two-thirds distance along inner edge from point of attachment, with two sub-equal setae at distal extremity.

Description of Male

General body proportions (fig. 2) very similar to those of female. Pre-maxillary appendages, and legs 1–4 all very similar to those of female, but slightly smaller.

Size.—Length to end of furcal rami 1.01 mm (mean of ten specimens).

Maxilla (fig. 1I).—Essentially like that of female but differing as follows: most proximal spine (that on anterior edge of distal segment) with larger secondary spinules especially along proximal half of distal edge (three or four spinules in this region, each about one-third length of main spine); total of nine spines (cf. seven in female), distal row with four large and four small spines (only three small spines or total of eight shown in fig. 1I).

Maxilliped (fig. 1K).—Three-segmented but grossly different from that in female, prehensile, terminal segment transformed into long curved claw with single seta close to proximal articulation, middle segment elongated and with swathe of spines restricted to elongated area facing claw, claw more than twice as long as middle segment.

Legs 5 (fig. 1P).—Reduced to about one-quarter size of those in female, lacking lobes on inner edge, with two terminal spines less reduced than segment.

Urosome.—Six-segmented (cf. five in female), segment two much enlarged (about twice as wide as segments 3–6, and slightly longer than segments 3 and 4 combined).

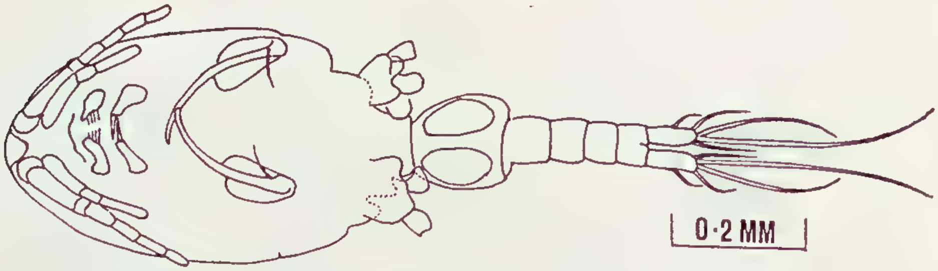


Figure 2.—*Kelleria australiensis* sp. nov., ventral aspect of ♂

III. KEY TO SPECIES

(Based on structure of maxilla and maxilliped of females as given in literature).

1. Two most proximal spines of maxilliped (those of middle segment or its homologue) not more than twice as long as basal width; terminal segment or portion of maxilliped lacking long spines (cluster of four sub-equal spines not more than three times basal width in length) .. .. *K. fucicola* (T. Scott), 1912

Two most proximal spines of maxilliped (those of middle segment) considerably more than twice basal width in length; terminal segment with at least one long seta or spine and usually more.............. 2

2. (1) Most proximal spine of maxilliped bifurcate 3
Most proximal spine of maxilliped not bifurcate 4

3. (2) Distal spine of middle maxilliped segment with stout secondary spur on proximal edge about half-way along length .. *K. regalis* Gurney, 1927
Distal spine middle maxilliped segment possibly with *series* of fine secondary processes along proximal edge but no single stout spur.. .... *K. rubimaculata* Krishnaswamy, 1952

4. (2) Distal maxilliped segment with 5 setae (or spines and setae).......... *K. propinqua* (T. Scott), 1894
Distal maxilliped segment with not more than 4 setae or spines 5

5. (4) Distal segment of maxilla terminating in one long curved claw, and with smooth proximal spine on anterior edge; distal maxilliped segment with only two setae .... *K. gurneyi* Sewell, 1949
Distal segment of maxilla with row of several spines along distal edge, and with denticulated proximal spine on anterior edge; distal maxilliped segment with three or usually four setae or spines 6

6. (5) Distal segment of maxilliped with three spines .... *K. purpurocincta* Gurney, 1927
Distal segment of maxilliped with four spines or setae 7

7. (6) Proximal spine of middle maxilliped segment with long hair-like processes (some more than half length of spine itself) along distal edge, proximal edge smooth or with only one secondary hair proximally 8
Proximal spine of middle maxilliped segment with short processes along both edges 9

8. (7) Inner lobe of basal segment of female fifth legs extending half-way along inner side of free (distal) segment .. *K. andamanensis* Sewell, 1949
Inner lobe of basal segment of female fifth legs extending only about quarter way or less along inner side of free segment .... *K. pectinata* (A. Scott), 1909

9. (7) Distal segment of maxilla with about 12 spines along distal edge (excluding proximal denticulated spine) .. *K. camortensis* Sewell, 1949
Distal segment of maxilla with six spines along distal edge (excluding proximal denticulated spine) .... *K. australiensis* sp. nov.

IV. DISCUSSION

It is clear that the structure of the maxillae and maxillipeds is of major importance in the taxonomy of this genus, and the characterization of these for some of the above species is inadequate. Thus the figure of the maxilla of *K. rubimaculata* (Krishnaswamy 1952, text-fig. 3e) is too small to be of much value, and the maxilla of *K. propinqua* is not figured at all. The structure of the mandible also seems to be important, but this has not been figured for *K. gurneyi*.

As indicated by the above key *K. andamanensis* and *K. pectinata* are closely related on the basis of maxilla and maxilliped structure, and the possibility that they are synonymous is perhaps worthy of investigation. They seem to be distinctly different, however, in the structure of the mandibles and the terminal armature of the antennae.

K. australiensis sp. nov. has no particularly close relationship with any of the previously described species. The fact that it lies adjacent to *K. camortensis* in the above key is not to be taken as implying close relationship with this species.

V. ACKNOWLEDGMENTS

I wish to thank Messrs G. H. Arnott and C. R. Campbell for collecting the material on which the above description is based. I am also indebted to Mrs J. Hope Black for identifying the gastropod and Mr R. J. King for plant identifications.

VI. REFERENCES

Gurney, R. (1927).—Cambridge expedition to the Suez Canal, 1924 XXXIII. Report on the Crustacea:—Copepoda (Littoral and Semi-parasitic). *Trans. Zool. Soc. Lond.* **22**: 451–577.

Humes, A. G. and Ho, J. S. (1969).—Cyclopoid copepods of the genus Kelleria (Lichomolgidae) from intertidal burrows in Madagascar. *Bull. Br. Mus. nat. Hist. (Zool.)* **18**: 221–9.

Krishnaswamy, S. (1952).—Some new species of copepods from the Madras coast. *Rec. Indian Mus.* **49**: 321–36.

Nicholls, A. G. (1944).—Littoral Copepoda from South Australia (II) Calanoida, Cyclopoida, Notodelphyoida, Monstrilloida and Caligoida. *Rec. S. Aust. Mus.* **8**: 1–62.

Scott, A. (1909).—The Copepoda of the Siboga Expedition. Part I. Free-swimming, littoral and semi-parasitic Copepoda. *Siboga Exped. Monogr.* **29a**: 1-323.

Scott, T. (1895).—Report on Entomostraca from the Gulf of Guinea, collected by John Rattray, B.Sc. *Trans. Linn. Soc. Lond.* **6** (1): 1–161.

Scott, T. (1912).—The Entomostraca of the Scottish National Antarctic Expedition 1902–1904. *Trans. Roy. Soc. Edin.* **48**: 521–99.

Sewell, R. B. S. (1949).—The littoral and semi-parasitic Cyclopoida, the Monstrilloida and Notodelphyoida. *Scient. Rep. J. Murray Exped.* 1933–34 *Lond.* **9** (2): 17–199.

Postscript

Since this paper was submitted for publication Humes and Ho (1969) have redescribed *K. regalis* and *K. pectinata* and also described the male of the latter species. These redescriptions do not influence the placement of these two species in the above key.

NATIONAL MUSEUM OF VICTORIA
19 OCT 1971

BALLS HEAD: THE EXCAVATION OF A PORT JACKSON ROCK SHELTER

By SANDRA BOWDLER

Department of Anthropology and Sociology, University of Papua and New Guinea

Plates 17–21. Figures 1–5. Manuscript received, 30th November, 1970

Balls Head is a small headland reserve jutting into the north side of Port Jackson west of the Harbour Bridge (Sydney sheet, map No. SI 56–5 grid ref. 420818). It has preserved its bushland appearance and been comparatively little interfered with. Vegetation consists of a mixture of indigenous and introduced trees and shrubs; grassy areas are maintained for the benefit of picnickers. Bedrock is Hawkesbury sandstone, with frequent outcroppings, particularly where the headland slopes steeply down to the Harbour. These outcroppings are in the form of both smooth, steep-sided or flat slabs and the characteristically weathered small rock shelters typical of the Sydney area. Many of the slabs are decorated with Aboriginal rock engravings and axe-grinding grooves, and some of the shelters bear rock paintings and hand stencils (Campbell 1899: 14, 17; Miles 1964: 343). There is not a great deal of other Aboriginal occupation evidence apart from the site under consideration, and thin open shell middens which may be detected beneath some of the grassed-over areas.

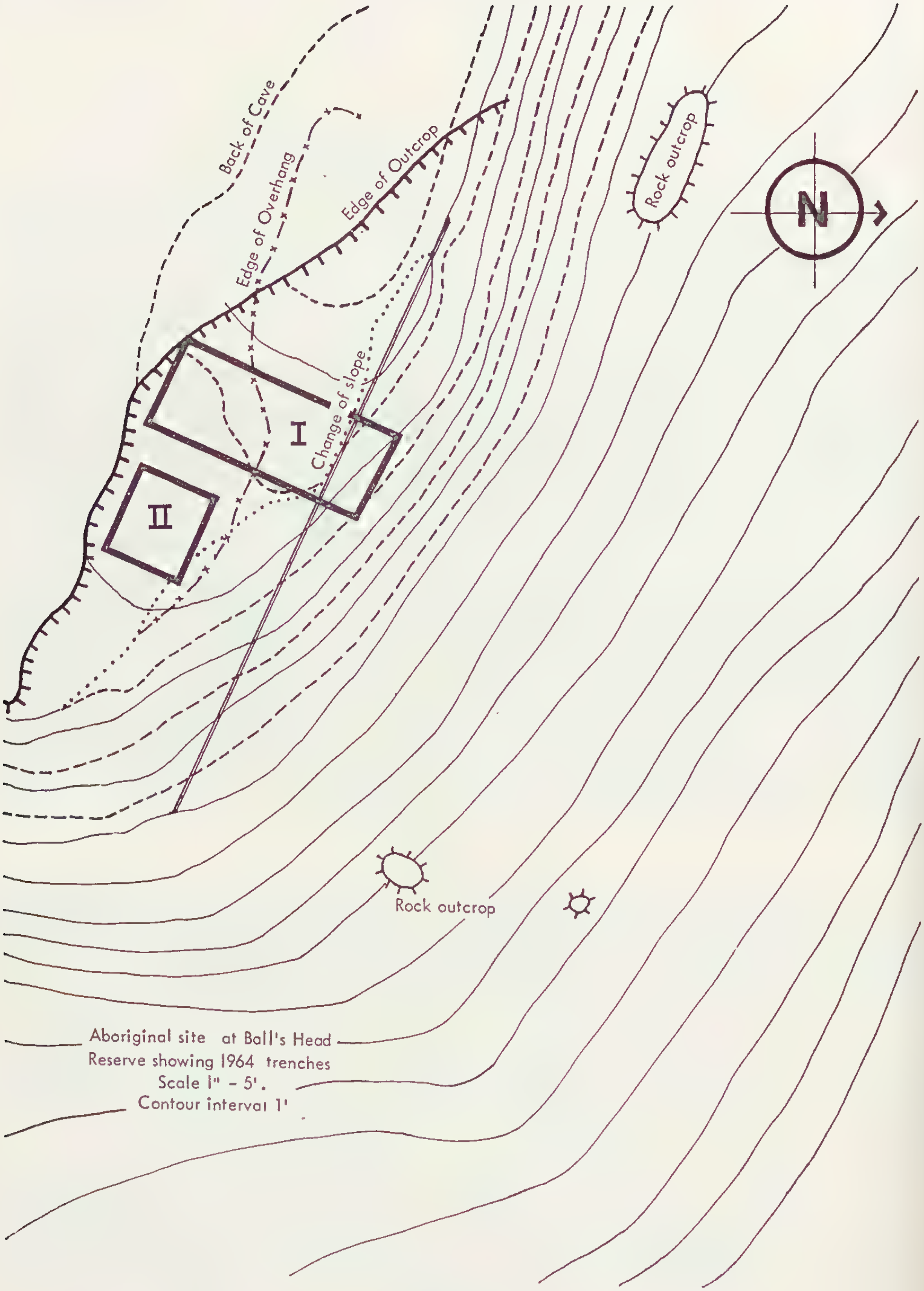
The rock shelter forming the subject of this paper is approximately 65 feet above mean water-level, of a north-easterly aspect (plate 17). It is not large: about 35 feet long, 7 feet from the drip-line to the back wall of the shelter, and 6 feet from ground surface to underside of overhang are its maximum dimensions (figs 1 and 2). Occupational deposit stretches from the back of the shelter, out beyond the drip-line for about 10 feet, where it then begins sloping downwards in a steep talus. There are faint hand stencils on the rear wall of the shelter and the roof is blackened, perhaps from the fires of the original occupants. The deposit consists of compacted shell midden, looser disturbed material, and less compacted midden. Its maximum depth is 2 feet 9 inches.

EXCAVATION

The original excavation was carried out under the direction of Mr Douglas Miles (then Assistant Curator in Anthropology, Australian Museum; now of the Department of Anthropology, University of Sydney), in April, 1964 (Miles, 1964). The discovery of a human skeleton in the deposit excited great public interest.

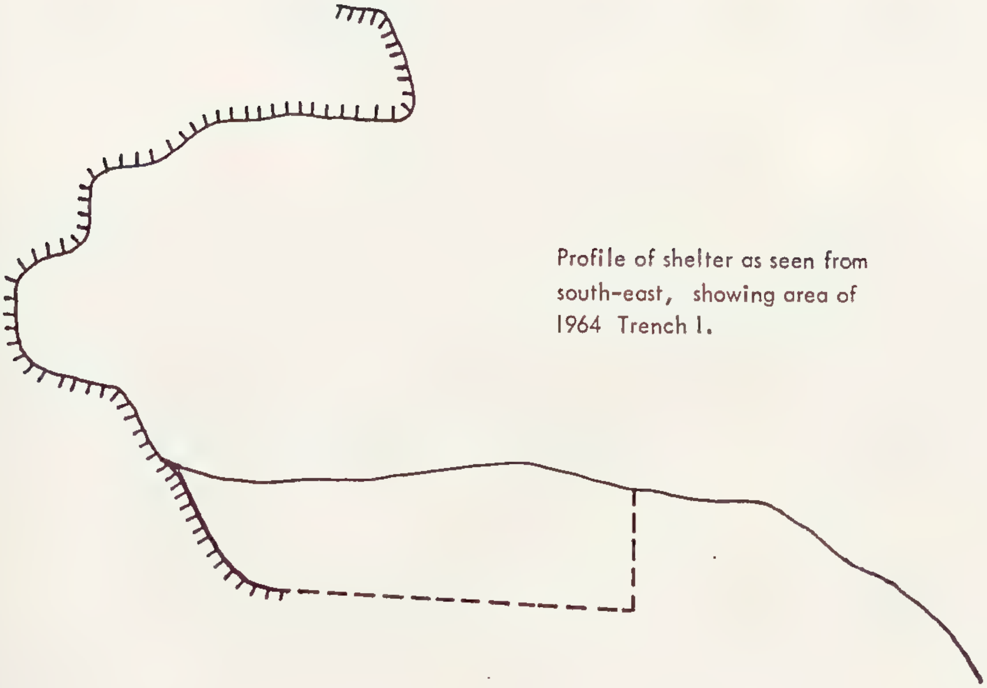
Two trenches were excavated, to which I shall refer as Trench I and Trench II, the latter being the more easterly (fig. 1). Deposit was removed in areas 2 feet square in 4-inch spits, and passed through sieves of 3/16-inch mesh. Trench I on completion extended 10 feet by 4 feet; Trench II, 6 feet by 4 feet, each with its long axis perpendicular to the rear wall of the shelter. The burial was found in Trench I.

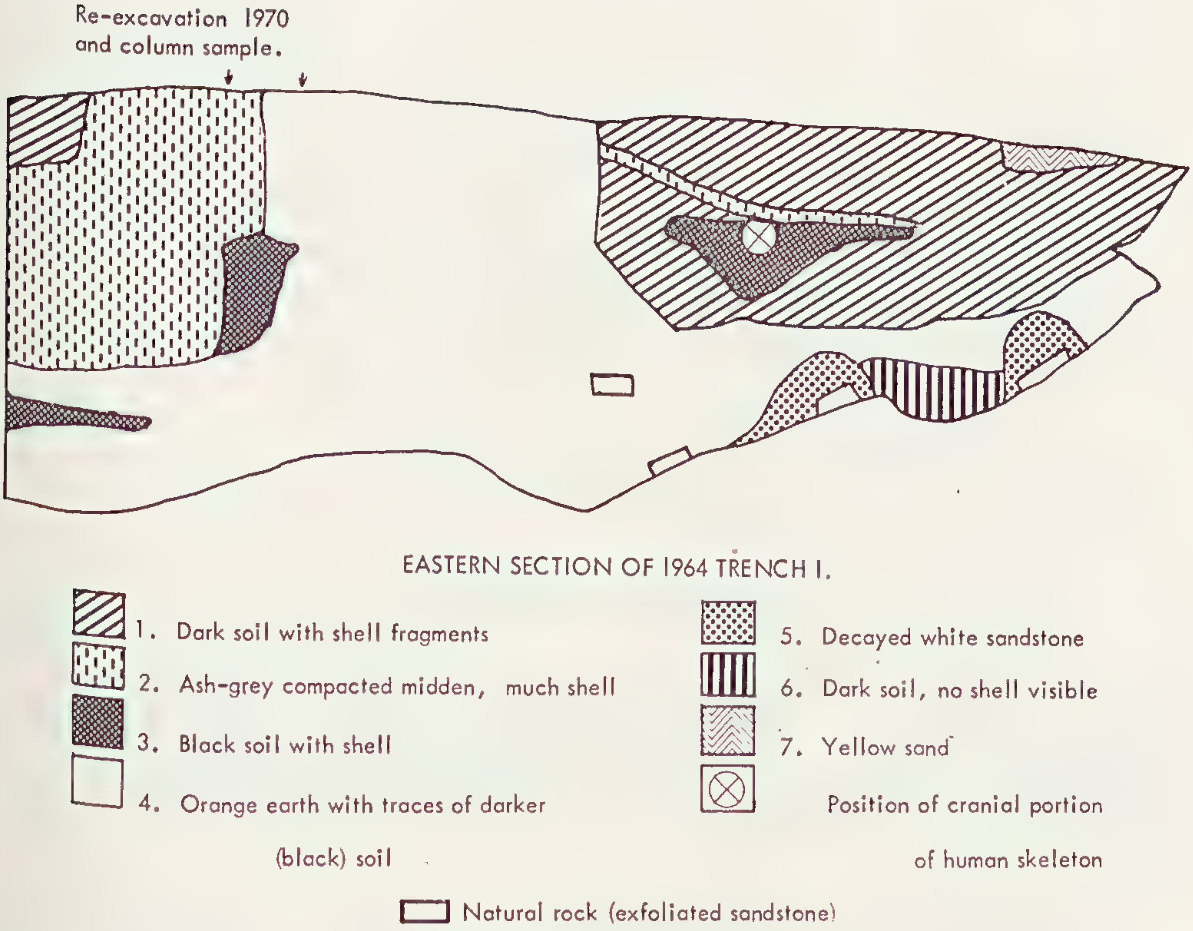
In January, 1970, I visited the site, accompanied by Mr Miles, who indicated the area of the 1964 excavations. These had been backfilled after excavation, but yellow sand had been used as fill to make re-location of the trenches easier. With the help of Mrs Jan Smith (Assistant in the Department of Anthropology, Australian Museum), Miss Kathleen Pope (formerly Assistant in the Department of Anthropology, Australian Museum) and Mr Peter Callaghan (Department of Archaeology, University



Aboriginal site at Ball's Head
Reserve showing 1964 trenches
Scale 1" - 5'.
Contour interval 1'

Figure 1




Re-excavation 1970
and column sample.
EASTERN SECTION OF 1964 TRENCH I.
▨ 1. Dark soil with shell fragments
2. Ash-grey compacted midden, much shell
3. Black soil with shell
4. Orange earth with traces of darker (black) soil
5. Decayed white sandstone
6. Dark soil, no shell visible
7. Yellow sand
⊗ Position of cranial portion of human skeleton
Natural rock (exfoliated sandstone)

Figures 2 (above) and 3 (below)

of Sydney), the 1964 Trench I was shovelled out to enable the section to be clearly visible. A small area, 1 foot by 2 feet, was excavated off the east face, thus exposed, for closer inspection of the stratigraphy, and a column 6 inches by 10 inches was removed to obtain a sample of the molluscan food remains. The whole area was then refilled.

STRATIGRAPHY (plate 18)

Fig. 3 is a diagrammatic representation of the eastern face of Trench I. Towards the front of the shelter (i.e., at the northern end) the deposit consists of strongly compacted shell in an ashy-grey matrix, which would result from many fires. McCarthy, in an unpublished review of the Sydney ethnography, says in reference to the use of rock shelters that "the fireplace was in the outer part of the cave" (McCarthy n.d.: 43; Bradley 1786-92: 103). I interpret this area of deposit as undisturbed. Beneath the midden stratum is a layer of orange sand, presumably weathered bedrock; this covers the bedrock itself. Most noticeable in the section is the profile of a large pit, over 2 feet wide and at least 18 inches deep. This would result from digging down into the lower orange sand through the midden, then refilling the lot. It is not an Aboriginal excavation to provide more living room, as such a feature would not have been immediately refilled, but would contain stratified midden material, as at Curracurang (Megaw 1966: 6, fig. 3). Pieces of modern bottle glass were found at the bottom of this pit. It was certainly not part of the 1964 excavation, and is best explained as the result of either vandalism or, perhaps, an early 20th century unpublished archaeological search for skeletons. The 1912 pickaxing of "Skeleton Cave", Inscription Point, Kurnell, in search of skeletal material, is an instance (Megaw 1968b: 17). The Balls Head burial (see below) appears to have been disturbed by this pit, which also truncates sharply a thin lens of ashy, compacted midden stretching from the southern margin of the pit towards the back of the shelter. This lens occurs in a thicker layer of looser, dark-brown material which contains less shell than the ashy midden. A segment of black earth containing shell occurs beneath the lens. A cross indicates the position of the cranial part of the skeleton: partly in the lens, partly in the darker soil. Further towards the back of the shelter the dark-brown material predominates, becoming perhaps looser towards the rear wall. Very close to the rear wall, in the top few inches of deposit, is a band of yellow sand. This may result from the 1964 backfilling, but it runs parallel to the back wall for at least 6 inches beyond the limits of the 1964 trench. It is highly possible that this back portion of the deposit has been also somewhat disturbed, but not to the depth of the orange sand.

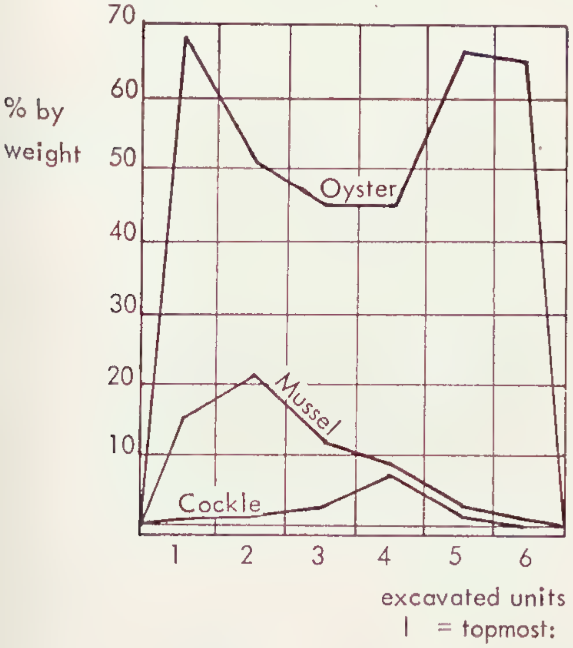
It was not possible to re-excavate Trench II. From inspection of photographs and field notes, I would guess that the rearmost 2 feet are possibly undisturbed. North of this, Trench II is intersected by the disturbance pit, and it seems safest to regard the northernmost 6 feet as disturbed.

DIETARY EVIDENCE

Apart from shellfish, food remains are extremely scanty. The only bones present besides human skeletal material are fragments of pig and other mammal from the surface, and about five extremely tiny fragments. These are unidentifiable except for one tooth and a dorsal spine of a fish. Mr Barry Goldman (Research Assistant, Australian Museum) thinks the former may be bream and the latter leatherjacket. The only other piece of identifiable non-human bone is a macropod incisor, discussed below.

A shell sample was removed in a column (see above). The shells from each spit were sorted into species and weighed. Species were identified by Mr Phil Coleman (Technical Assistant, Australian Museum), whom I thank also for his helpful comments. The predominant food mollusc by weight was the rock oyster *Crassostrea commercialis* (Iredale and Roughley), and it was predominant throughout the site's occupation.

The next most important was the hairy mussel *Trichomya hirsuta* (Lamarck), which showed an increasing importance from the bottom up. The Sydney cockle *Anadara trapezia* (Deshayes), on the other hand, while never as important a food source as the others, showed a reverse tendency to *Trichomya*, increasing in proportion towards the bottom of the deposit (Fig. 4: graph showing respective weight percentages). Bearing in mind the usual *caveats* about column samples (Ambrose 1967: 177, 182, 183 and *passim*; Lampert 1966: 98), it is interesting to note that the Sydney cockle is now virtually extinct in Port Jackson; perhaps as its numbers decreased, mussels came to be more heavily relied on. The larger blue-black edible mussel, *Mytilus planulatus* (Lamarck), not one specimen of which could be identified in the Balls Head deposit, is now abundant in the Harbour and in the foreshore area below the site, at least on European structures. It has been thought by zoologists that the large edible mussel, so similar to that of the Old World, was a European introduction (Miss Elizabeth Pope, Curator of Worms and Echinoderms, Australian Museum: personal communication). This would explain the Balls Head situation, but is shown to be false by the occurrence of *Mytilus planulatus* (or *edulis* Linn.) in a definitely pre-European context at the midden site of Durras North (Lampert 1966: 89).



Results of column sample showing relative importance through time of Crassostrea commercialis (oyster), Trichomya hirsuta (mussel) and Anadara trapezia (cockle).

Figure 4

Another species, the large mud oyster *Ostrea angasi* Sowerby, is represented by a few shells; it, also, is effectively extinct in Port Jackson. No specimens occurred in the column sample, but were found in other parts of undisturbed midden deposit, all from more than 12 inches below the surface—the same point at which Sydney cockles begin to decline.

For other species present, see appendix.

No artefacts of shell could be detected. A single operculum of *Turbo* (*Ninella*) *torquata* Gmelin, the turban shell, was found. This mollusc occurs generally on the open rocky shore and is the usual raw material for shell fish-hooks (Lampert 1966: 113).

ARTEFACTS

The total number of stone artefacts excavated is 450. This comprises 42 implements, 2 cores, 4 "fabricators" (scalar cores: J. P. White 1968) and 402 waste flakes. Implements types are: microliths 13; thumbnail scrapers 2; other scrapers 9;

miscellaneous secondary working 6; utilized flakes 12. One of the 9 scrapers is made on an artefact previously used as a fabricator/scalar core: this would bring the core total to 7 (fig. 5).

The most numerous and interesting of the implements are the microliths (as defined by Glover and Lampert 1969: 225). Ten of these are of geometric form: 2 trapezes, 5 segments, 2 crescents, 1 triangle (fig. 5; McCarthy 1967: 41–2 and fig. 25). The triangle has been modified on the margin opposing the two backed margins, adding weight to the suggestion that this was the utilized edge. One other microlith is broken; one is of amorphous shape. One only approximates the asymmetric form of the classic Sydney-South Coast "Bondi Point". Glover's criterion for distinguishing geometric microliths from other backed forms, such as Bondi Points, is that the former have a length/breadth ratio of less than 2:1, the latter one of more than or equal to 2:1 (Glover 1967: 419). This has the advantage of being more objective than a purely morphological assessment, and applied to the Balls Head sample (complete specimens only) gives the following results:

L:B ratio range:	1.1–1.4:1	1.5–1.9:1	2.0–3.0:1
Number of specimens:	5	5	2

L:B ratio total range: 1.1–3.0:1 mean: 1.6:1

Of the two microliths with length:breadth ratio over 2:1, one is the asymmetric backed blade mentioned above, the other is a "segment" (2.1:1). However, I continue to include the latter in the geometric microlith category, as morphologically it is clearly not an asymmetric backed blade (fig. 5), thus facilitating comparison with other Sydney sites. In any case, a comparison of the above figures with those cited by Glover (1967: 424) shows we are here dealing with an unusual suite.

Two problems are raised by this microlithic component. Firstly, this is a most unusual suite for the Sydney region in particular. The usual ratio is a predominance of asymmetric backed blades with a subordinate number of geometric forms (McCarthy 1943: 132–3; McCarthy 1948: 7, 11–12; McCarthy 1964: table 3; Wade 1967: 37; R.V.S. Wright, Department of Anthropology, University of Sydney, for Smith's Creek and Murramurra Creek: personal communication). That this reversal of a more usual norm at Balls Head is not necessarily due to the smallness of the sample is shown by a comparison with the Connel's Point site where, of an equally small sample, the microlithic component is:

Elouera 1; Bondi Points 4; crescent 1; miscellaneous backed 4 (Wade *loc. cit.*) Or: 1 geometric form to 9 others; whereas Balls Head has 10 geometric forms to 3 others, morphologically. I tested the significance of these figures with a Chi-squared test (using Yates' correction for a small sample), with the result that $X^2 = 13.002$ which with one degree of freedom gives a probability of less than 0.001; that is, there is less than one possibility in a thousand that the predominance of geometric forms at Balls Head is due to chance. As against all this, however, Glover comments on the result of a factor analysis of material from Curracurang:

> Terms such as Bondi Point, crescent, triangle and point were shown to be useless for organizing the implements into distinct types based on the characteristic patterns of a number of attributes. They are better seen as a single but rather variable group . . . (Glover 1969: 46).

The second problem is that the microlithic tool kit known from other well-stratified sites in the area usually gives way to fabricators/scalar cores, *Elouera* in some cases, and greater numbers of undifferentiated small flakes as the major types found (Wade 1967: 37; Megaw 1968a: 326–8; Hume 1965: 22, 24; McCarthy 1948: 11–12). The change-over for the Sydney region dates to approximately 1,000 years ago (Megaw 1966: 12; Megaw 1968a: 328). At the Balls Head site vertical distribution of implement types appears to be undifferentiated; microliths occur from the surface to the bottom of the deposit. Six occur in the top 12 inches; the rest below 12 inches. Given the disturbed nature of the site, this may not be significant. In the part of the site which I would regard as positively undisturbed—the front

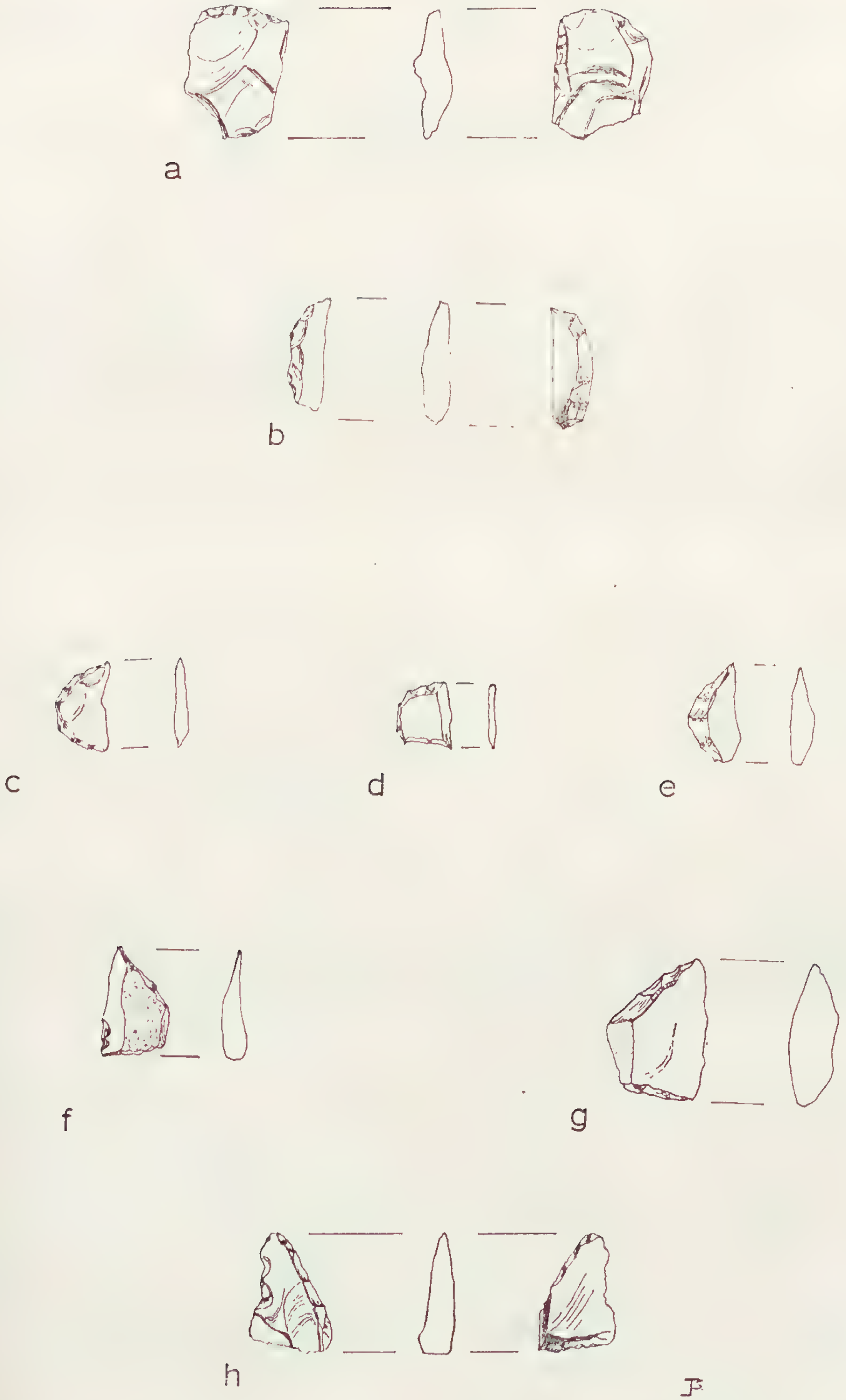


Figure 5.—Stone Artefact Types (about two-thirds natural size): a, fabricator made on a scraper; b. asymmetric backed blade; c-h, geometric microliths

portion with ashy, compacted midden—no microliths occur. One fabricator/scalar core was found here, between 8 and 12 inches below the surface. The rear portion of Trench II, which may be tentatively regarded as undisturbed, has microliths as follows: one between 8 and 12 inches; 6 below 12 inches; and a fabricator/scalar core in the top 4 inches. The other microliths occurred in areas very likely to have been disturbed (the rear of Trench I, further forward in Trench II). Two fabricators/scalar cores were found in the region of the disturbance pit, also the scraper/fabricator. Hence the site is not necessarily an exception in terms of sequence of stone implements through time.

There, is, however, a very marked horizontal distribution within the site: all microliths occurred towards the rear of the shelter: 11 in the rearmost 2 feet of both trenches, two between 2 and 4 feet from the rear wall in Trench II. Six are in a possibly undisturbed context. There is also a difference in the artefact totals. For the following figures, "Back" = the rearmost 4 feet of Trench II plus the rearmost 2 feet of Trench I (the area of the microliths): "Front" = the rest of the site excavated

	Microliths	*Scrapers*	*T'nail Scr.*	*Misc.*	*Utilized*	*Cores*
Front:	0	7	1	4	8	4
Back:	13	2	1	2	4	2
	13	9	2	6	12	6

	Implements	*Waste*	*Implements as % of waste + implements*
Front:	20	132	15.2%
Back:	22	264	8.3%
	42	396	

(The second table excludes 6 primary flakes in a bag of which the 1964 label has decayed: these have obviously been excavated but their exact provenance cannot be determined).

Did more industrial activity take place in the rear of the shelter? The two ratios implements: waste are not of greatly significant difference statistically; $X^2 = 3.523$, so, with one degree of freedom, $p =$ between 0.10 and 0.50. However, as percentages the differences may be of some significance technologically: 15.2% is much higher than usual when stone is being flaked *in situ*, whereas 8.3% is closer to the norm. Moreover, the area of Back is 24 square feet; that of Front is 40 square feet. Average depths of deposit are Front: 2 feet; Back: 18 inches, giving volumes of Front: 80 cubic feet and Back: 36 cubic feet. Total artefact counts are Back: 288 and Front: 156. Therefore densities work out at: Front, 1.95 artefacts per cubic foot; Back: 8 artefacts per cubic foot. Hence, I would conclude that less industrial activity did in fact take place in the front of the shelter, where perhaps stone tools were *used* with greater frequency; and microliths are found in the back of the shelter because they were made there. Perhaps they were not used at the site at all; could the absence of mammalian food remains be related to this? Most of the implements from the front of the shelter are those which are generally regarded as being used in the manufacture of other, usually wooden, tools, namely scrapers and utilized flakes. At Balls Head it may be that flaking of stone was carried on in the rear of the shelter because the ground was flatter, and it was out of the way of cooking, eating and the making of non-stone implements.

Artefacts of European origin included some heavily patinated, thick pieces of glass, some possibly flaked, and some lumps of melted lead in conjunction with very small spherical pellets of lead. The glass occurred in the top 4 inches of the front undisturbed midden and may indicate that the site was inhabited by Aborigines into early colonial days. The lead comes from more disturbed areas. Some larger pieces are obviously fishing sinkers of quite modern type; however, Mr Miles suggests that the small balls and lumps may represent musket shot being manufactured within the shelter itself.

THE BURIAL (plates 18, 19, 20, 21)

Miles' original statement that the burial was found to be in a pit is arguable (Miles 1964: 345). The major pit visible in the section is later in time than the burial, and indeed appears to have disturbed it. The darker stratigraphic unit in which the skeleton was resting may represent a shallow pit, or may be a soil discoloration due to the presence of the body itself. No obvious grave goods were found, but in the vicinity of the maxilla was a lower incisor of a juvenile macropod, sub-family Potoroinae (identified by Mr B. J. Marlow, Curator of Mammals, Australian Museum). Examination of this tooth under a microscope revealed traces of a dark material which may possibly be a vegetable gum. I interpret it as a decoration worn by the deceased in the head region, either stuck in the hair or on a necklace. The burial is that of a female (see below); McCarthy refers to Phillip, who "did not see any head ornaments on the Botany Bay women". However, he also quotes Govett, who "stated that the hair of the women whom he saw was shorter than that of the men, and that the wives of 'chiefs' attached kangaroo teeth in a band, stuck on with black wax, all around their head". Also, necklets and circlets utilizing macropod (and other) teeth were worn by Sydney women (McCarthy n.d. 162–3; Britton (ed.) 1892: 132; Govett 1836: 218).

The human remains are not in a good state of preservation, and the long bones visible in plates 19 and 20 are now missing from the Museum, although an extensive search was made for them. The skeleton was examined in the field by Mr Alan Thorne (Department of Anatomy, University of Sydney), who recalls that it was somewhat disturbed. Mr Peter Thompson (Australian Institute of Aboriginal Studies) examined the photographs and fragments still remaining, and makes the following comments:

> All measurements of teeth, jaws and other bones suggest a small individual, almost certainly female. Wear of the teeth is considerably advanced, suggesting an age in excess of 30 years. Sub-nasal prognathism and advanced tooth wear suggest that it is an Aboriginal skull.

Bones remaining are: maxilla and part of frontal bones; mandible; all teeth; some hand and foot bones; a piece of rib; right and left leg bones and various fragments. Visible in plates 19, 20, and 21 are the right arm bones. Mr Thompson suggests these are somewhat disarranged but not seriously disturbed. Drawings and photographs suggest that the body was oriented east-west with the cranium to the east—that is, crosswise across Trench I. However, if they were lying in a more or less undisturbed position and the rest of the bones were disturbed by the large pit, this must mean that the body was lying face-down, on its stomach, a most unusual position. The legs would have stretched out in an opposite direction to Trench II; a left patella (knee bone) fragment in the top 4 inches of Trench II suggests further disturbance.

Miles also suggests (a) that the burial may have been a cremation, and (b) the presence of "post holes" may indicate a kind of canopy or platform over the body or on which it rested (Miles 1964: 345). Mr Thompson finds no evidence whatever of burning on the human skeletal remains. The post holes appear to me to be leached-out tree-roots; large trees occur on the periphery of the deposit and roots are numerous within it. Furthermore, those discussed by Miles are in the yellow sand in Trench II so are unlikely to have been associated with the burial.

Mrs Betty Hiatt, who is currently working on Australian burial customs (as an M.A. thesis topic for the Department of Anthropology, University of Sydney), comments *in litt.* that for the Sydney area "there is historical evidence to suggest that corpses were (either) abandoned, buried (or) cremated" (see also B. Hiatt, 1969). The Balls Head burial would appear to have been either interred or abandoned, more probably the former. There are no comparable modern excavations of burials within

Port Jackson, but Mr Peter Thompson and myself have examined all skeletal material in the Australian Museum from a Port Jackson locality or nearby (excluding material from south of Tom Uglys Point). Most of these were excavated or discovered in the late 19th or early 20th century. Given such limitations it was obviously impossible to determine whether each was an interment or abandonment, but it *was* possible to ascertain whether any had been cremated. Mr Thompson assigned an approximate age and sex to each. Of a sample of 20 or more (some represented more than one individual from a single locality, often mixed together), not one showed any sign of having been burnt. Six were juveniles, 1 a teenager, 13 were mature. Of the latter, 7 were probably female, 5 probably male, 1 possibly male. Seven came from rock shelters, the rest from either open foreshore midden sites or merely listed localities (e.g., "Port Jackson", "Harbord" etc.). This is not a large sample but, firstly, shows a reasonable cross-section of age and sex and, secondly, demonstrates that burial in a living area was not unusual. Mrs Hiatt remarks that though "there is no really good archaeological evidence for cremation . . . this is not surprising, given the nature of the custom and the fact that it was probably performed away from living areas". Thus the Balls Head burial, while not a cremation, is a fairly typical Port Jackson inhumation.

CONCLUSIONS

The following points may be noted:

1. Not much food was eaten at the Balls Head rock shelter apart from shellfish (and presumably unpreserved vegetable foods);
2. There are quite a large number of stone implements;
3. Of these, a surprisingly high proportion are microliths of geometric form;
4. A burial contained in the deposit is of a mature Aboriginal female, unexceptional except for its position, which may be due to the fact that:
5. The deposit is exceedingly disturbed.

The first point is interesting in view of the abundant historical observations of Aborigines fishing in Port Jackson (Lawrence 1968: 139–55). Such skeletal remains as are preserved are in a sufficiently good state of preservation to suggest that if others were once there they have not simply decayed. The large amounts of shell in the front and undisturbed part of the deposit would provide a good environment for the preservation of other faunal remains.

At the Chicago symposium on hunter-gatherers, Deetz remarked on the "peculiar difference between the evidence of hunting and the evidence of gathering in terms of what is preserved" (1968: 282); and other participants likewise deplored the lack of "archaeological visibility of food-gatherers" (Binford *et al.* 1968: 285–7). However, this is not always so. The symposium also agreed that the collecting of shellfish should, as an activity, be placed in the category of gathering, rather than fishing (Lee 1968: 41; Suttles 1968: 61n.). Hence any shell midden displays a high degree of archaeological visibility of food-gatherers—which is to say, women. In most areas of Aboriginal Australia, it is the women who gather the shellfish (B. Hiatt 1970; Basedow 1935: 76; L.R. Hiatt 1965: 3, 25; Roth 1901: 7; Thomson 1949: 21; Wells 1963: 127; C. White 1969: 2–3; Lawrence 1968: 158, 176). However, for the Sydney region Lawrence notes three historically observed instances of men collecting shellfish (1968: 43). In two of these cases, intensive gathering need not necessarily be indicated: Cook's account (Beaglehole ed. 1955: 311) describes men gathering shellfish from their canoes, and Hunter (1793: 63) saw men diving into the surf for shellfish. Neither method would seem to provide the reliable bulk of shellfish meat ensured by the more methodical on-foot gathering by women; indeed, the latter method would be inapplicable within the Harbour. I suggest that the bulk of molluscan remains preserved in the Balls Head shelter is most likely the fruit of women's gathering activities.

Binford and Binford draw a distinction between "maintenance" and "extractive" types of hunter-gatherer sites (1966: 268–9). While one may have reservations about such a neat dichotomy, it is tempting to envisage the Balls Head shelter as a predominantly maintenance site, where hunting gear was manufactured and repaired while people subsisted on the easily gathered shellfish. As the use and manufacture of stone implements are generally the preserve of Aboriginal men, we may perhaps conclude that at Balls Head women extracted while men maintained.

APPENDIX: Shellfish species present in deposit

Identified by Mr Phil Coleman, Technical Assistant, Australian Museum

Crassostrea commercialis (Iredale and Roughley), the rock oyster.
Trichomya hirsuta (Lamarck), the hairy mussel.
Anadara trapezia (Deshayes), the Sydney cockle.
Ostrea angasi Sowerby, the mud oyster.
Siphonaria sp.; *Notoacmea* sp. poss. *flammea mimula* Iredale, limpets.
Bembicium melanostoma (Gmelin).
Prothalotia comtessei Iredale.
Cacozeliana lacettina (Gould).
Velacumantis australis (Quoy and Gaimard), the Australian mud whelk).
Austrocochlea concamerate Wood, periwinkle.
Pyrene sp.
chitons sp.
possibly *Venerupis* sp.
possibly *Chioneryx candioicles* (Lamarck).
Endodont sp., land snails.
Galeolaria sp., fragments, the limy tube worm (identified by Miss E. Pope, Curator of Worms, Australian Museum).

None of these (except the first four) are likely to have been a food source of any importance, and were probably brought to the site attached to other shells. The following did not occur in the column sample but probably provided an intermittent food source, occurring singly in other parts of the deposit:

Pyrazus ebininus Bruguiere, the Hercules club whelk.
Chama jukesi Reeve (used to be *fibula*), the southern chama.

The general similarity of this list to the sample from the Gymea Bay site will be noted (McMichael in Megaw and Wright 1966: 47).

ACKNOWLEDGMENTS

I thank the Director and Trustees of the Australian Museum for a grant in aid and the use of the facilities of that institution. Mr J. V. S. Megaw, Mr Wilfred Shawcross, Mr John Clegg and Miss Elinor Crosby read this paper in an early form; I am grateful for their suggestions and criticisms, but they are in no way responsible for any remaining errors. I thank all those mentioned in the text, and particularly Dr J. P. White, Mr Doug Miles, Mr Peter Thompson and Mrs Jan Smith, whose help was invaluable. Drawings of artefacts were done by Mrs Smith; all other drawings are the work of the Exhibitions Department, Art and Design Section, Australian Museum. Figure I is based on an original survey by Mr Shatwell, of the Department of Mines. Photographs were taken by Mr C. V. Turner and Mr Howard Hughes, both of the Australian Museum.

BIBLIOGRAPHY

Ambrose, W. R., 1967: "Archaeology and Shell Middens", *Archaeology and Physical Anthropology in Oceania* II (3): 169–87.

Basedow, Herbert, 1935: *Knights of the Boomerang*, Sydney.

Beaglehole, J. G. (ed.), 1955: *The Journals of Captain Cook, I: the Voyage of the Endeavour* 1768–1771, Cambridge, Hakluyt Society, extra series XXXIV.

Binford, L. R. and Binford, S. R., 1966: "A Preliminary Analysis of Functional Variability in the Mousterian of Levallois Facies" in J. D. Clark and F. C. Howells (eds.) *Recent Studies in Paleoanthropology, American Anthropologist*, 68 pt. 2.

Binford, L. R. *et al.*, 1968: Discussion of "Archaeological Visibility of Food-gatherers" in Lee and De Vore (eds.): 285–7.

Bradley, Lt. William, 1786-92: *A Voyage to New South Wales* 1786-92, Public Library of N.S.W., Sydney, 1969.

Britton, A., 1892: *Historical Records of New South Wales I* (2): *Phillip*, 1783–1792, Sydney.

Campbell, W. D., 1899: *Aboriginal Carvings of Port Jackson and Broken Bay*, Memoirs of the Geological Survey of N.S.W., Ethnological Series no. 1, Sydney.

Deetz, James, 1968: "Hunters in Archaeological Perspective" in Lee and De Vore (eds.): 282.

Glover, I. C., 1967: "Stone Implements from Millstream Station, W.A.: Newall's Collection Re-analysed", *Mankind* 6 (9): 415-25.

Glover, I. C., 1969: "The Use of Factor Analysis for the Discovery of Artefact Types", *Mankind* 7 (1): 36–51.

Glover, I. C., and Lampert, R. J., 1969: "Puntutjarpa Rockshelter Excavations: by R. A. Gould: a Critical Review", *Archaeology and Physical Anthropology in Oceania* IV (3): 222–8.

Govett, W. R., 1836: "Sketches of New South Wales", *Saturday Magazine* 8 (252): 218.

Hiatt, Betty, 1969: "Cremation in Aboriginal Australia", *Mankind* 7 (2): 104–119.

Hiatt, Betty, 1970: "Woman the Gatherer", in Fay Gale (ed.) Woman's Role in Aboriginal Society, Australian Institute of Aboriginal Studies, Canberra.

Hiatt, L. R., 1965: *Kinship and Conflict*, Canberra.

Hume, S. H. R., 1965: *The Analysis of a Stone Assemblage to Determine Change*, unpublished B.A. (Honours) thesis, Department of Anthropology, University of Sydney.

Hunter, J., 1793: *An Historical Journal of the Transactions at Port Jackson and Norfolk Island* . . . London.

Lampert, R. J., 1966: "An Excavation at Durras North, New South Wales", *Archaeology and Physical Anthropology in Oceania* I (2): 83–118.

Lawrence, Roger, 1968: *Aboriginal Habitat and Economy* A.N.U., Canberra.

Lee, Richard B., 1968: "What Hunters do for a Living, or, How to Make out on Scarce Resources", in Lee and De Vore eds. (1968).

Lee, R. B. and De Vore, I. (eds.), 1968: *Man the Hunter*, Chicago.

McCarthy, F. D., 1943: "An Analysis of the Knapped Implements from Eight *Elouera* Industry Sites", *Records of the Australian Museum*, Sydney, 21: 127–53.

McCarthy, F. D., 1948: "The Lapstone Creek Excavations: Two Culture Periods Revealed in Eastern New South Wales", *Records of the Australian Museum*, Sydney, 22: 1–34.

McCarthy, F. D., 1964: "The Archaeology of the Capertee Valley, New South Wales," *Records of the Australian Museum*, Sydney, 26: 197–264.

McCarthy, F. D., 1967: *Australian Aboriginal Stone Implements*, Australian Museum, Sydney.

McCarthy, F. D., n.d.: *Artists of the Sandstone*, unpublished typescript.

Megaw, J. V. S., 1966: "Report on Excavations in the South Sydney District, 1964–65", *Australian Institute of Aboriginal Studies Newsletter*, 2 (3): 4–15.

Megaw, J. V. S., 1968a: "A Dated Cultural Sequence for the South Sydney Region of New South Wales", *Current Anthropology* 9 (4): 325–9.

Megaw, J. V. S., 1968b: "Trial Excavations in Captain Cook's Landing Place Reserve, Kurnell, New South Wales", *Australian Institute of Aboriginal Studies Newsletter* 2 (9): 17–20.

Megaw, J. V. S. and Wright, R. V. S., 1966: "The Excavation of an Aboriginal Rock Shelter on Gymea Bay, Port Hacking, N.S.W." *Archaeology and Physical Anthropology in Oceania* I (1): 23-50.

Miles, Douglas, 1964: "Preliminary Comments on the Balls Head Archaeological Excavation", *Australian Natural History* 14 (11): 343–5.

Roth, Walter E., 1901: "Food: its Search, Capture and Preparation", *North Queensland Ethnography: Bulletin No.* 3, Brisbane.

Suttles, Wayne, 1968: "Coping with Abundance: Subsistence on the North-west Coast", in Lee and De Vore eds.

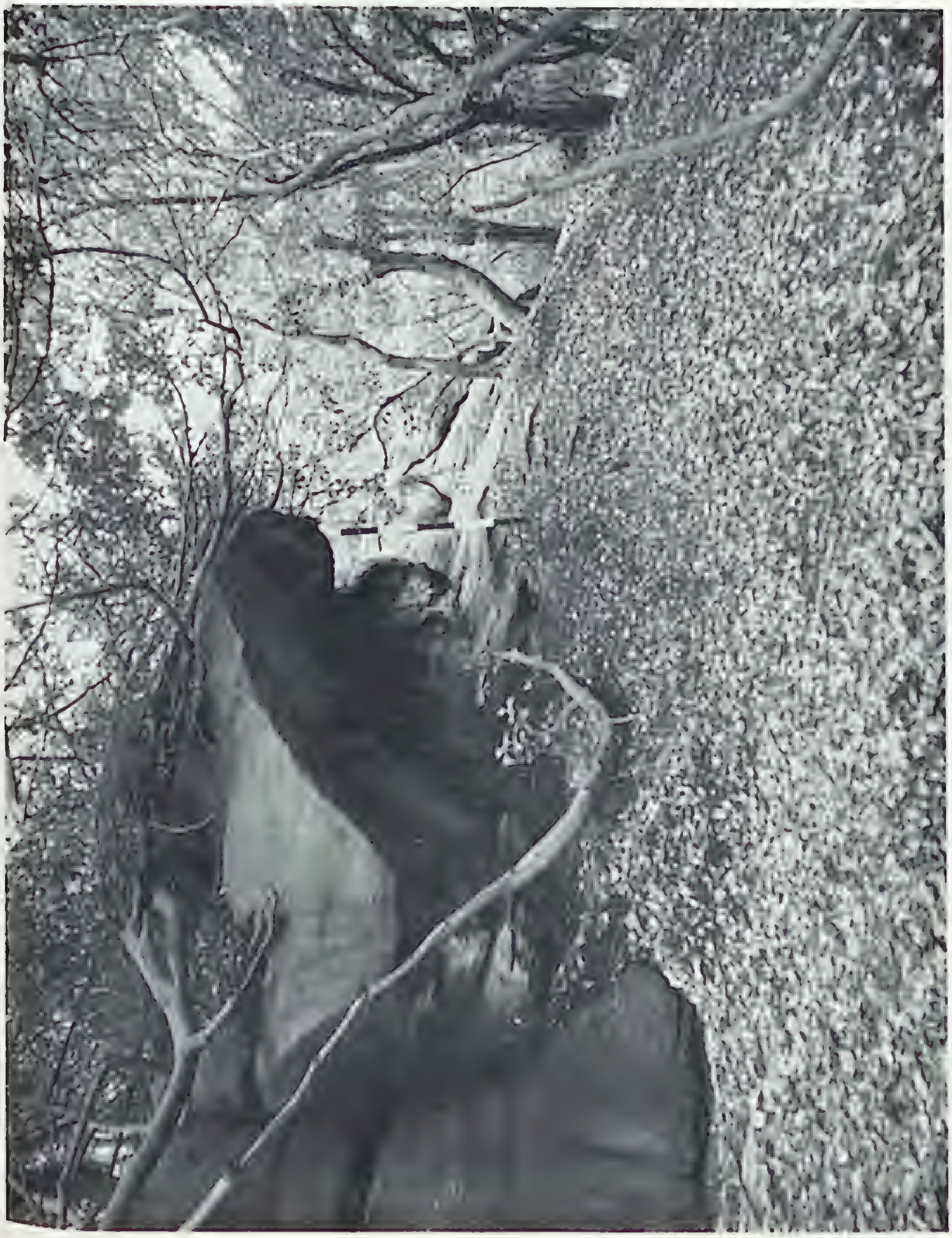
Thomson, Donald F., 1949: *Economic Structure and the Ceremonial Exchange Cycle in Arnhem Land*, Melbourne.

Wade, J. P., 1967: "The Excavation of a Rock-shelter at Connel's Point, New South Wales", *Archaeology and Physical Anthropology in Oceania* II (1): 35–40.

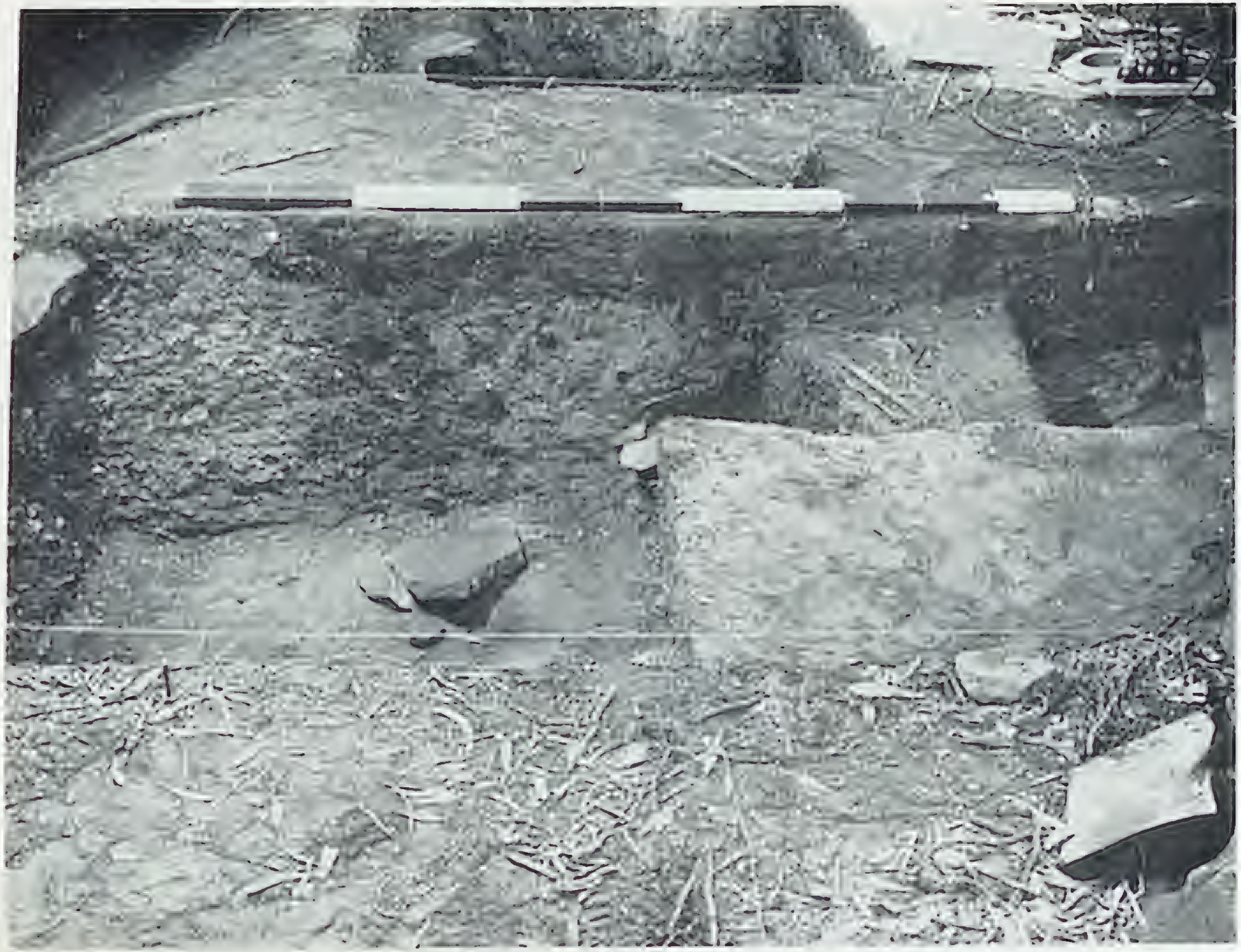
Wells, Anne E., 1963: *Milingimbi: Ten Years in the Crocodile Islands of Arnhem Land*, Sydney.

White, Carmel, 1969: "Report on Field Trip to Caledon Bay, Northern Territory, Dec./Jan. 1968–9", Australian Institute of Aboriginal Studies Document No. 69/816 (roneoed typescript).

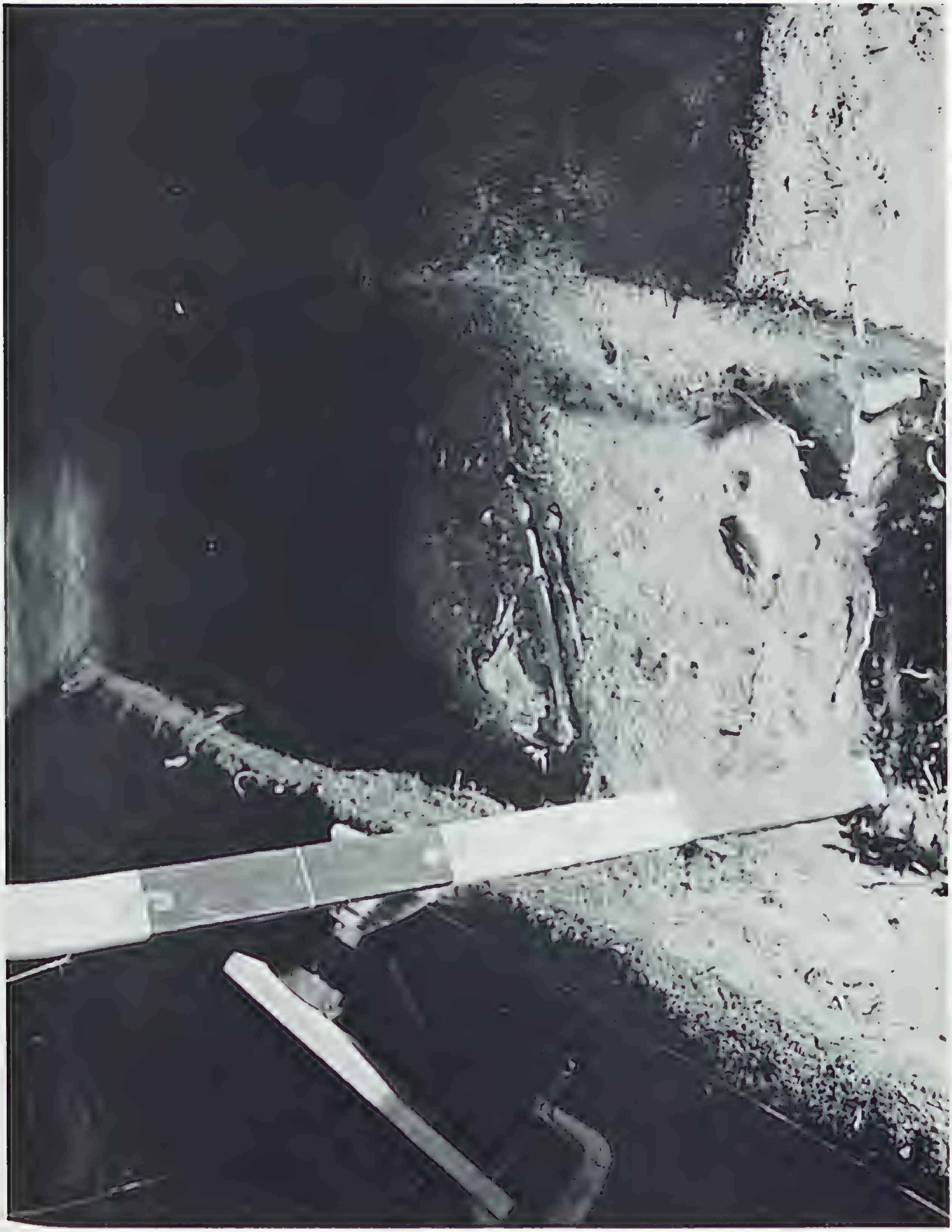
White, J. Peter, 1968: "Fabricators, Outils Écaillés, or Scalar Cores?" *Mankind* 6 (12): 658–65.



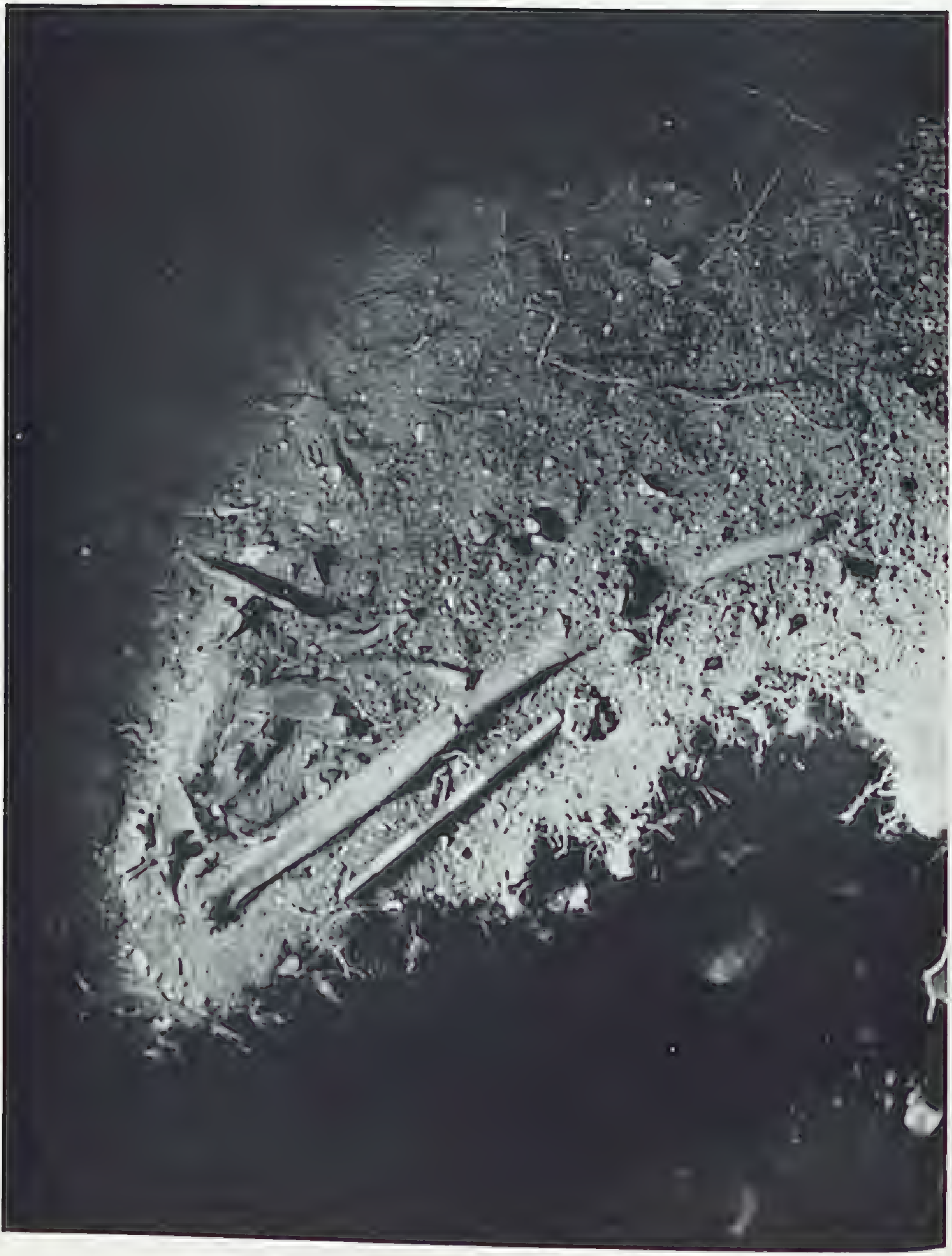
Balls Head rock shelter, general view from east



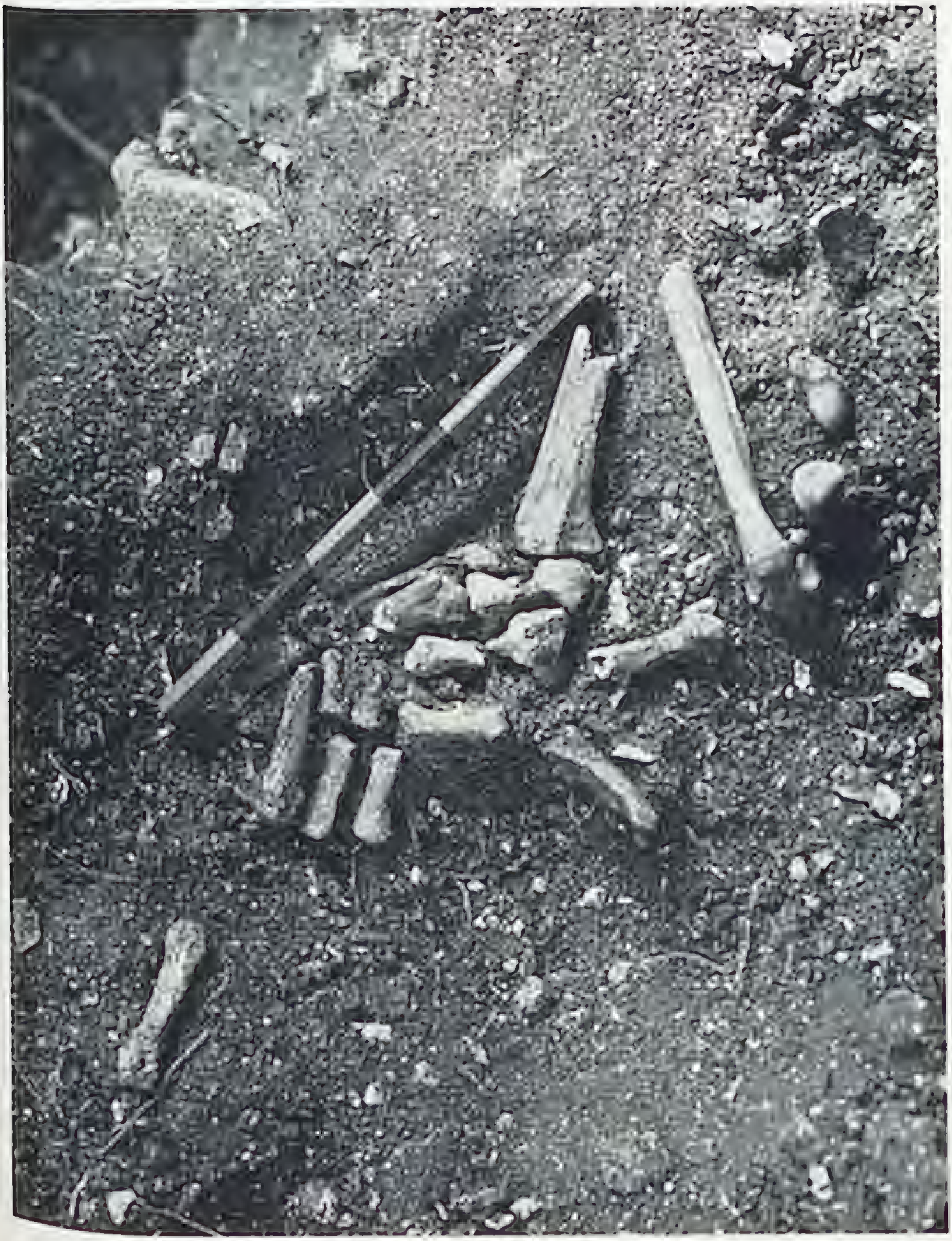
Trench I from west: skeletal material in *situ* to right of disturbance pit; compacted shell midden on left (scale in feet)



Right arm bones of skeleton *in situ*



Right arm bones of skeleton *in situ*



A third view of the right arm bones of the skeleton *in situ*

Bassianobdella fusca sp. nov. (Hirudinoidea: Richardsonianidae), with an Initial Demonstration of Systematic Values in the Lengths of Annuli in the Mid-Nephric Somites[1]

NATIONAL MUSEUM OF VICTORIA
28 MAR 1972

By LAURENCE R. RICHARDSON[2]

Figures 1 and 2. Manuscript received 22nd October, 1970.

ABSTRACT

The new species is distinct in having the annuli subequal in length in the somites of the middle group of the nephric series. The bassianobdellid elongate cylindroid form of the ejaculatory bulbs, and elongate U-shape of the caecate vagina, are shown to be primary morphological forms.

The requirements of an aquatic sanguivorous habit impose a rigid discipline on the morphology of 34 somites in jawed sanguivorous leeches which, accordingly, are animals exhibiting a high measure of monotony in their general morphology. Qualities such as behaviour, muscularity, colour, etc., which readily separate closely similar species in life, vanish or diminish with death and preservation, leaving the systematist the difficult task of finding morphological separation in species which are similar in pattern, in general meristic morphology, jaws, dentition, and the other readily accessible criteria utilized in the classification of leeches for the past 150 years.

With failure in this, the indications of speciation observable in live leeches have been disregarded, and for nearly 100 years the majority of "species" have been defined where separation has been possible on distinctive morphological features present in some leeches. The approach to the assessment of the nature of speciation has been further complicated by the elementary and totally inadequate definition of genera.

The seven-banded bassianobdellid leeches are now known from Tasmania to southern Queensland. Over this range, they are essentially similar in general somital annulation, the location of external landmarks, pattern, the topography of pattern, jaws and dentition, with colour ranging from black through shades of brown, to olive. As such they would have been recognized until recently as a single species, which, lacking salivary gland papillae and copulatory gland pores, and with 16 complete 5-annulate somites, would have been placed in *Limnobdella*.

---

[1] A study assisted by a grant from the Nuffield Foundation in support of researches on Australian leeches.

[2] 4 Bacon Street, Grafton, N.S.W. 2460.

Having established systematic values in the morphology of the reproductive systems, pharynx, etc., at familial and generic levels in hirudiniform leeches (Richardson, 1969a), it has been shown (Richardson, 1970) that the bassianobdellids include leeches of two genera: *Bassianobdella*, Bassian; and a Torresian genus. This and other demonstrations of the inadequacy of the earlier classification do not resolve the confusion at the species level, nor can this be resolved in revisions in the use of the earlier criteria. In describing here a third species of *Bassianobdella*, attention can be drawn for the first time to the potential systematic significance in the diversity of annulation in the middle group of nephric somites.

In the pre-Linnean and early post-Linnean periods, species were described in the "classical" manner: colour, pattern, total number of annuli, annular location of landmarks (eyes, genital pores, anus, etc.), teeth, geographic origin; and the hirudiniforms placed in the European genera *Hirudo* and *Haemopis* (or their equivalents). Before Whitman (1886), a few new genera were established on differences in the position of landmarks (e.g., *Oxyptychus* Grube 1851, 4 annuli between the genital pores); on peculiarities such as: a deep groove on the lower surface of the "lip" of the anterior sucker, a very large posterior sucker (*Limnatis* Moquin-Tandon 1826); a complex of copulatory gland pores (*Macrobdella* Verrill 1872, with many fine teeth, s.g. *Philobdella* Verrill 1874 with 20 teeth); lacking jaws and with many ridges in the pharynx (*Semiscolex* Kinberg 1866).

Whitman demonstrated the presence of 15 "somites" having 5 complete annuli in *Hirudo medicinalis*, as also in a Japanese aquatic jawed sanguivore which he accordingle placed in *Hirudo*; 16 such "somites" in *Macrobdella* and in Japanese leeches which lack copulatory gland pores, and on these terms he provided *Leptostoma* (now *Whitmania*) for the Japanese species. Whitman, following the examples of Grube and Moquin-Tandon, provided *Hirudinaria* as a new genus for *Hirudo javanica*, this having 7 annuli between the genital pores and a very large sucker. In this way there was established the nature of the genus for aquatic hirudiniforms as used for the next 80 years.

Moquin-Tandon (1846) described 21 varieties of colour and pattern in *Hirudo medicinalis*, 11 in *Haemopis sanguisuga*. Converting this interpretation of wide variation in colour and pattern in the species into a principle that these were generally without systematic value, and adding to Whitman's generic criteria the presence or absence of a median groove on the ventral aspect of the "lip" of the anterior sucker and also of salivary gland papillae on the jaws, R. Blanchard, from 1891 on, reduced hirudiniform and haemadipsine species described in the classical manner in various Regions to synonymy under the earliest named species in the Region; e.g., 15 such in the Oriental Region became synonyms of *Hirudo granulosa* Savigny 1822. This, having salivary gland papillae on the jaws, Blanchard (1897) transferred to the Circum-Mediterranean *Limnatis*, placing it in a s.g. *Poecilobdella* since *granulosa* has more than 100 teeth on the jaw and metameric maculations.

Established on limited criteria which are now proven neither specific nor generic in value, Blanchard's "megaspecies" in the aquatic and terrestrial jawed sanguivorous leeches have created confusion for nearly all workers since 1900. This can be seen in Johansson (1911), who figures some 10 differing patterns in *Hirudo australis* Bosisto 1859, including here leeches of three Australian genera, one recognizably bassianobdellid; and in Moore (1927), who was partially successful in subdividing Blanchard's megaspecies *L. granulosa* in terms of the morphology of the median regions of the reproductive systems, but as this was used at both the subgeneric and specific levels, Moore gave no clear indications for others to follow. Because of a separation of their leeches into genera on morphological criteria other than those of Whitman and Blanchard, Caballero and Ringuelet have had a considerable measure of success in the determination of species in the Neotropical jawed leeches. Caballero utilizes systematic values in colour and pattern; Ringuelet, variation in the position of external landmarks and in the morphology of the reproductive systems, both differing in a measure not seen in other faunas.

With the Australian leeches, it has been possible to validate *Hirudo elegans* Grube 1867, a species described in the classical manner (Richardson, 1969b); to show, as also with leeches of other Regions, the inadequacy of genera formulated on the principles of Whitman, Blanchard, and their followers (Richardson, 1969a and c, 1971b and c); to demonstrate the nature of generic differentiation among leeches which are highly monotonous in general somital annulation, pattern, etc. (1969a and c, 1970, 1971b and c); and now, among such leeches, to show systematic values in the variety of annulation in the middle group of nephric somites.

Since Whitman (1886), it has been accepted that a complete 5-annulate condition is found only in the somites of the nephric region, viii to xxiv. It is found on all (total 17) in a few genera (*Aetheobdella*, Australian Region; *Whitmania*, Oriental; one species of *Oxyptychus*, Neotropical); generally (25 of the 28 currently known genera) the genera have either ix to xxiv (total 16), or ix to xxiii (total 15); 14 such, only in *Myxobdella*, Oriental. Whitman's practice directs attention to the anterior and posterior nephric somites, viii and xxiv.

Moore was meticulous in recording the detailed annulation of all somites in many species from various Regions for over 30 years from 1901. He recognized (1927) three groups of somites in the nephric series: an anterior group, viii to x, xii or xv, somites in which the relative lengths of the annuli change from somite to somite in a progression which expresses the ontogeny of somital annulation that Moore (1900) had described; a middle group in which the relative lengths of annuli are the same in all somites; and a posterior group, xix or xx to xxiv, again with progressional change in the relative lengths of annuli. Following Whitman and Blanchard, Moore gave systematic value only to the annulation of the initial somites in the anterior group and terminal somites in the posterior group. The extensive data on annulation of the middle group remained embodied in specific descriptions. It was not given systematic value. Later, Moore abandoned description of the annulation of the middle group of somites.

Those very few (Ringuelet, Meyer, Richardson) who have followed Moore in the intimate description of the complete somital annulation in aquatic jawed sanguivores, have also followed him in directing attention to the initial and terminal somites in the nephric series. With an anticipation that the distribution of somites among the three groups might possibly have value, I attempted to determine the precise limits of the groups. This fails because the change from one group to the other is commonly gradual, not abrupt. I find that even with excellent material I often have no confidence in the determination of the limiting somites of the anterior and posterior groups.

With expanding experience of the Australian leeches, it has become obvious that the somites of the middle group in the nephric series may have:

A. Annuli all of the same length, $b_1 = b_2 = a_2 = b_5 = b_6$;

B. Annuli all of differing length, $b_1 < b_2 < a_2 > b_5 > b_6$, when the sequence by length is $a_2 > b_5 > b_6 > b_2 > b_1$;

C. Some annuli equal and differing in length from others, in combinations of $b_1 <$or$= b_2 <$or$= a_2 =$or$> b_5 =$or$> b_6$.

Moore has described these conditions in leeches from other Regions.

Some of the conditions now known for somites in the middle group of the nephric series in Australian leeches are:

A. All equal, somites xii to xxi. *Goddardobdella elegans*, Torresian; 2 species of a Torresian genus of bassianobdellid-like leeches; 2 species of *Richardsonianus*, central eastern N.S.W.

B. All of different lengths. Not recognized here as yet, excepting on the posterior somites of the anterior group in C_4 below.

C. Some equal, differing in length from others.

1. $b_1 = b_2 < a_2 = b_5 = b_6$: *Bassianobdella* sp. nov. as below, central eastern N.S.W., exhibiting two series: xv to xvii, a_2 very closely similar in length to all of the "b" category; xviii to xxi, with a_2 slightly but recognizably longer than b_1 and b_2.
2. $b_1 = b_2 < a_2 > b_5 = b_6$. *Bassianobdella victoriae*, Victoria. (Preserved material, somital range uncertain.)
3. $b_1 = b_2 < a_2 = b_5 > b_6$. Somites ix to xviii. Gen. et sp. nov., southern Western Australia. A genus of the "*australis*"-complex with xxv 5/5- or 4/5-annulate (Richardson, 1971d).
4. $b_1 < b_2 < a_2 = b_5 > b_6$. Somites x to xviii. *Bassianobdella* sp. nov., Tasmania (Richardson, 1971a).
5. $b_1 < b_2 = a_2 = b_5 > b_6$. Somites xiv to xxiii. *Richardsonianus* sp., southern eastern N.S.W.

In C. 2. to 5. above, the greater length of a_2 and its equivalents is quite distinct in live material, well extended preserved specimens, and with some experience recognizable in poorer preserved material. In the latter, it is difficult to assess differences in relative length of annuli of the "b" category.

Genus **Bassianobdella** Richardson 1970

Richardsonianidae; 16 complete 5-annulate somites; xxv, 4-annulate; teeth minute, about 45 to 50; no salivary gland papillae on the jaws; pharynx terminating at viii/ix; primary caeca median on crop compartments; ejaculatory bulbs elongate, cylindroid, folding in contraction; median regions, bimyomeric, mesomorphic, both formed on a primary loop, the caecate vagina formed on the elbow and extending along the posterior portions of the procurrent and recurrent limbs to be elongate, U-shape with subequal limbs, the procurrent limb tapering into a moderately muscular vaginal duct distinctly shorter ($\frac{3}{4}$ or less) than the recurrent limb of the vagina; common oviduct not associated intimately with the vaginal duct or the body of the vagina.

Size, medium. Pattern, continuous longitudinal dark bands, a median dorsal and three pairs of dorsal bands.

Type species: *Bassianobdella victoriae* Richardson 1970, by monotypy; Bassian (Victoria).

In the original separation of *Bassianobdella* from the Torresian genus (Richardson, 1970), the relative lengths of the common oviduct and of the vagina were proposed as a primary generic feature. This has been found incorrect (Richardson, 1971a). Comparison of the female median regions in a 21.0 mm specimen and an 81.0 mm specimen in the new species below shows that growth during general growth and functional differentiation is greater in the muscularized portion of the primary loop than in the non-muscularized common oviduct, agreeing with the principle which was earlier proposed (Richardson, 1969a) that the effects of differentiation are greater on the bursal portion of the primary loop than on the atrial portion. Since the vaginal duct and vagina are equally influenced in growth and differentiation, the relative lengths of the two structures provide a primary morphological characteristic of generic value.

Bassianobdella fusca sp. nov.

(Figs 1, A to F; 2, G and H)

Holotype: Deposited Australian Museum, Sydney, reg. no. W 4297. Length, 81.0 mm. Dissected, right ventrolateral jaw removed, mounted separately. Evans Plain Creek, from a side-pool just above the Mitchell Highway, 6 miles east of Bathurst, altitude 1,800 feet, tributary to the Macquarie River. Dec. 4, 1969. Coll. L. R. Richardson.

Paratype: Deposited National Museum of Victoria, Melbourne, Coll. No. G. 1909. Length, 81.0 mm. Dissected, left ventrolateral jaw removed, mounted separately. Same locality, date, collector, as holotype.

Type locality: A lower transitional section of a small sandy-bottom stream averaging about 6 feet wide by 1 foot deep, with secure well-grassed banks about 4 feet high. Taken from a small, deep, side pool divided from the main stream by a sand bank nearly closing off the head of the pool. Associated: 6 specimens of *Richardsonianus* sp. No other *B. fusca* found during 1½ hours search over a length of 300 yards of stream.

The following description is taken from the holotype.

General form

In life: elongate, moderately depressed, the margins sharp ridged; swimming, elongate, depressed to be strongly flattened, the margins sharply keeled along the greater length of the postclitellar region. The leech is strongly muscular and readily escapes from the tightly closed hand.

Preserved: Depressed, elongate, widening progressively from the velum to the clitellum, which is well formed and the widest region of the body; narrowed slightly behind this with the margins parallel to the postnephric region where, it narrows abruptly to form the base, two-thirds of the width of the sucker which is slightly narrower than the general width of the body. The depth increasing to the clitellum, and essentially uniform along the postclitellar region.

Total length, 81.0 mm; width at iv/v, 2.0 mm; at vii/viii, 3.5 mm wide and 2.0 mm deep; at x/xi, 6.0 mm wide, 3.5 mm deep; at xiv/xv, 5.0 mm wide, 3.5 mm deep and of these dimensions back to xxiv/xxv, 75.0 mm from the tip of the velum; the base of the sucker, 3.0 mm wide; the sucker, 4.0 mm in diameter.

Colour

In life: generally dark greenish-brown above, the venter paler; the median band, black; paired dark bands, brownish-black; the light stripes, dark greenish-brown; margins, pale.

Preserved in alcohol: the general colour diminishes to a pale light-grey, the venter much paler light-grey; median band, black; paired dark bands, pale grey, uniform; supramarginal field, dark grey; the stripes, pale light-grey, almost off-white; dorsum of the sucker, immaculate dark-grey. Venter, immaculate.

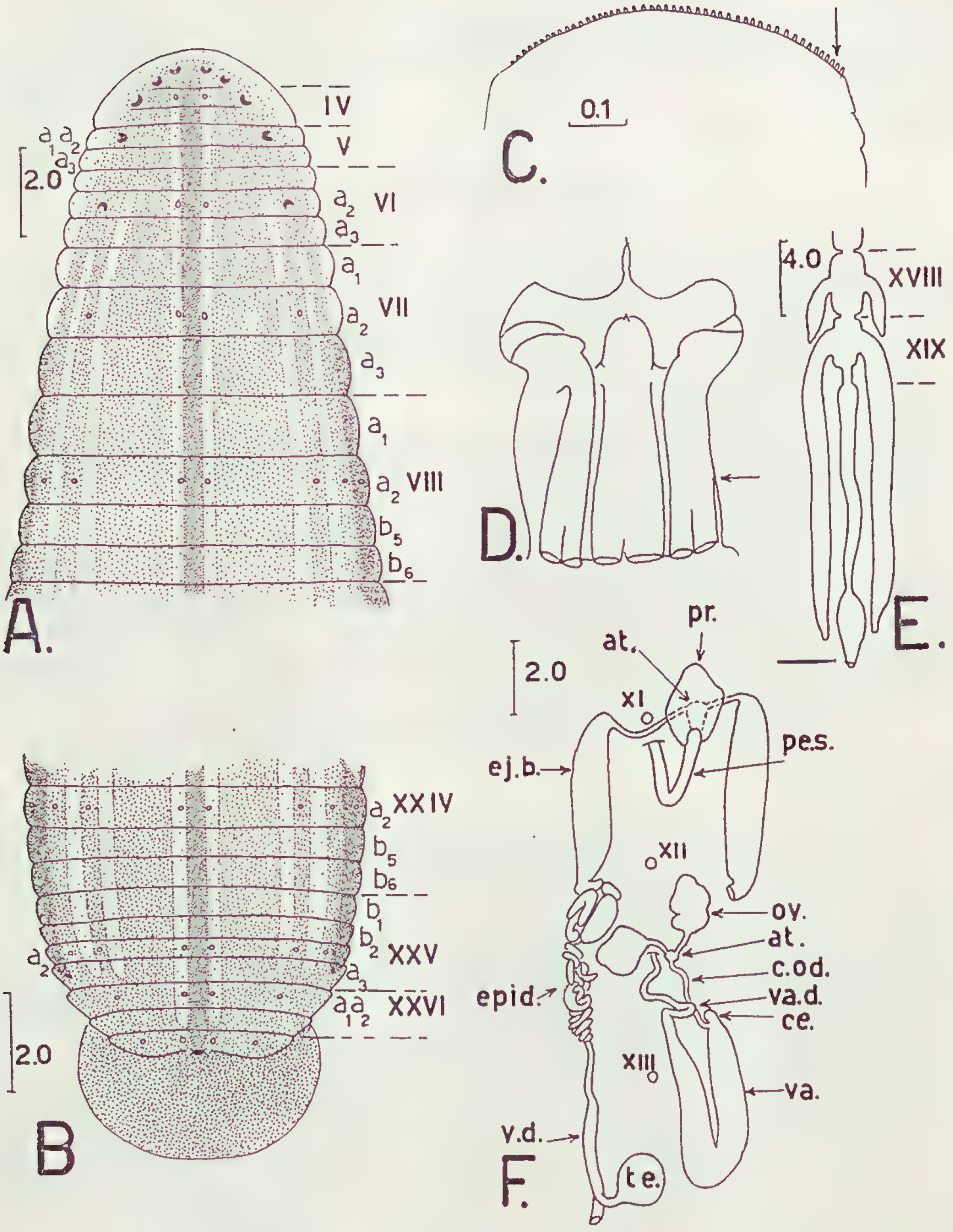


Figure 1, A to F.—*Bassianobdella fusca* sp. nov. Dorsal annulation, A somites i to viii, and B somites xxiv to xxvii. C, left ventrolateral jaw of paratype (arrow indicates medial end). D, pharynx opened along mid-ventral line to show jaws and internal muscular ridges (arrow marks mid-point in length of pharynx). E, crop, caecation, somites xviii and xix; intestine; rectum. F, anterior region, male paired ducts; male median region; female reproductive system. Illustrations from the type, excepting C from the paratype. Somites and somital ganglia indicated by Roman numerals; annuli, "a_2", etc. Somital ganglia represented at relative size. All scales in mm. Abbreviations: at, atrium; ce., caecum; c.od., common oviduct; ej.b., ejaculatory bulb; ej.d., ejaculatory duct; epid., epididymis; ov., ovary; ovd., oviduct; pe.s., penis sheath; pr., prostate; te., testis; va., vagina; va.d., vaginal duct; v.d., vas deferens.

Pattern (*Fig.* 1, *A*, *B*)

The ocular arch enclosed in a dark ocular area. Three pairs of light stripes, inner, middle and outer pairs, separate the narrow median, inner, middle and outer paired dark bands, the outer continuous with the distinctly darker supramarginal band. (See paratype and other material.)

The inner paired stripes commence at iii/iv, include the paramedian sense organs closer to the medial edge of the stripe, extend briefly into the paramedian field, and terminate in xxvi a_3, defining between them the median black band which continues to the posterior border of xxvii and is slightly wider than the adjacent stripes for most of its length. The middle paired stripes are narrow, of uniform width, wider than the inner pair, commence at v/vi, terminate at xxv/xxvi and are lateral in the paramedian field. Between the inner and middle stripe, the paramedian field is occupied by the inner paired bands which increase in width as this field widens posteriorly. The outer paired stripe is of the width of the inner stripe, uniform in width along its length, commences in vi a_3, extends along the intermediate field and terminates at xxv/xxvi. The middle and outer stripes define the middle paired dark bands which extend along the line of the intermediate sense organs, briefly into the adjacent fields, and are uniform in width. The outer paired band is of the width of the middle paired band, uniform, extends along the line of the supramarginal sense organs from in vi to xxv/xxvi. The dark margin occupies the supramarginal field, includes the marginal sense organs, and is sharply set off from the pale submarginal field which is continuous with the venter.

The dark paired bands join into the dark patch across xxvi and xxvii which is continuous with the uniform dark dorsum of the sucker.

Annulation (*Fig.* 1, *A*, *B*)

Preserved: Interannular and intersominal furrows equivalent, strongly defined; somital limits not directly recognizable; annuli not showing as distinct couplets or triplets; somital sense organs small, obscure, detectable as in small white patches on the dorsum, but only with great difficulty on the venter; sensillae, not obvious, but in the clitellar and postclitellar regions, a very fine white line divides the annuli at the level usual for the sensillae and shows white points similar in size to sensillae; nephropores obvious in small white spots on a_1 or b_2 just medial to the intermediate line of sense organs.

The thin margin of the velum incised in the paramedian and intermediate lines, carries the 1st and 2nd pairs of eyes and a weak furrow ii/iii between the intermediate lines; iii/iv, distinct between the same limits; iv, 2-annulate with the 3rd pair of eyes and 1st obvious paramedians in $a_1a_2>a_3$; iv/v extending onto the margin so that the dorsolateral lobe of the margin of the sucker is well defined; v, 2-annulate above, the 4th pair of eyes in a_1a_2 slightly $<a_3$, a_1a_2/a_3 terminating at the marginal line with uniannulate v essentially forming the lateral and ventral margin of the sucker; vi, 3-annulate above, a_1 slightly $<a_2<a_3$, the 5th pair of eyes in a_2, a_1/a_2 weak, reaching to the supramarginal line and vi 2-annulate on the margin and below where $a_1a_2>a_3$; vii 3-annulate above and below, $a_1<a_2<a_3$; vii a_3 and viii a_1 almost subequal (refer to paratype and other material); viii 4-annulate, $a_1>a_2$ slightly $>b_5>b_6$, the 1st nephropores on a_1; ix to xxiv complete 5-annulate (total 16); ix, $b_1 = b_2<a_2 = b_5>b_6$; x, $b_1 = b_2<a_2 = b_5<b_6$, x a_2 the 1st annulus of the clitellum; xi, $b_1 = b_2<a_2<b_5 = b_6$; xii, $b_1 = b_2 = a_2 = b_5>b_6$; xiii, $b_1 = b_2 = a_2>b_5>b_6$, xiii b_5 the last annulus of the clitellum; xiv, $b_1 = b_2<a_2>b_5 = b_6$; from xv to xxi, a_2 detectably longer than annuli b_1 and b_2 but not significantly longer and all are closely similar in length so that a_2 is not recognizable by length alone, $b_1 = b_2$ slightly $<a_2 = b_5 = b_6$; xxii, $b_1 = b_2<a_2>b_5 = b_6$ with a_2 recognizably longer than b_2, as also in xxiii, $b_1 = b_2<a_2 = b_5>b_6$; xxiv, $b_1 = b_2>a_2>b_5>b_6$, with the last nephropores on b_2; xxv, 4-annulate, $b_1>b_2 = a_2$ slightly $<a_3$, with a_3 the last annulus complete across the venter; xxv a_3 very slightly $>$ xxvi a_1a_2; xxvi, 2-annulate, $a_1a_2>a_3$, the somital sense organs all median in the length of a_1a_2; xxvi/xxvii complete across the dorsum; xxvii, uniannulate; the anus at the posterior border of xxvii. The dorsum of the sucker with 6 concentric furrows; omital sense organs obscure.

Alimentary tract (Fig. 1, C, D, E)

Jaws small, compressed in profile at the medial end and obtusely rounded, slightly taller than the width at the base; housed in deep grooves, almost pocket-like but with poorly formed margins; a distinct deep median fissure extending on the lower surface of the velum, anteriorly from the groove housing the dorsomedian jaw but not incising the margin of the velum; the dental ridge, long, low convex, 0.7 mm in length; the teeth about 45 (but the ridge distorted and the number not accurately countable), 0.020 mm long at the medial end and diminishing very gradually; no salivary gland papillae on the jaws.

The mouth little wider than the base of the dorsomedian jaw; the lumen of the pharynx, narrow, tubular, tapering; six internal muscular ridges joining rather far back in the pharynx as pairs forming ventrolateral and dorsomedian ridges, each entering the base of the appropriate jaw; no ridges ending independently between the bases of the jaws.

The pharynx commences vii/viii, terminates at viii/ix; extrinsic radial muscles, an obvious system extending into ix; dorsal salivary glands, numerous as cords of gland cells forming poorly defined right and left masses each with thick cords of aggregated ducts; the crop constricted into compartments, narrowly tubular in ix and x; tubular with indications of one pair of small simple caeca at the median level in xi, as also in xii (the compartments in x, xi, and xii restricted by the thick layer of clitellar gland cells associated with the well-formed clitellum); in xiii, a pair of distinct caeca at the median level, the caeca elongate, tubular and extending into the paramedian chambers, as also in xiv; xv, similar but with the caeca extending into the anterior annuli of the following somite, as also xvi, xvii and xviii; in xix, the postcaeca originate along the lateral aspects of the anterior half of the compartment, and behind this the compartment is reduced, tubular, and joins the intestine terminally at xix/xx; the intestine, inflated, tubular, tapering terminally to join at xxiii/xxiv to the end of the rectum which terminates at the anus. The postcaeca are inflated, simple, and terminate in xxvi.

Reproductive system (Fig. 1, F)

The indications are that the specimen is nearing female maturity.

The genital pores are at xi and xii b_5/b_6; the ejaculatory bulbs, elongate cylindroid; the median regions, bimyomeric, mesomorphic, the vagina U-shaped with a vaginal duct.

Testes, simple saccular, 10 pairs, the first pair at xiii/xiv, the last at xxii/xxiii (the vas deferens continues briefly beyond the 10th vas efferens, turns medially into the median chamber, suggesting the possibility for 11 pairs); vasa deferentia extend along the floor of the paramedian chamber, reduce in diameter in the middle of xiii, and the male duct continues as the tubular, folded and convoluted epididymis in the contiguous halves of xiii and xii, becoming more broadly tubular before opening into the ejaculatory bulb in the middle of xii; ejaculatory bulbs, elongate, cylindroid, muscular, extend to the level of ganglion xi, connecting medially by short, narrowly tubular ejaculatory ducts to the male atrium; the atrium, muscular, continuous with the muscular cylindrical penis sheath formed on a posteriorly directed loop, reflecting at xi/xii to end at the genital pore.

The saccular thin-walled ovaries are in the posterior half of xii, connecting by short oviducts to the well-formed thin-walled atrium at the level of the female pore; female median region formed on a posteriorly directed loop extending from the atrium to the genital pore and reflected at xiii/xiv; the common oviduct occupies the first one-third of the recurrent limb, connecting subterminally to the vagina, which has a small caecum, completes the recurrent limb and continues more than half-way along the procurrent limb, where it tapers to become a narrow muscular vaginal duct loosely folded on itself before terminating at the genital pore. The vagina is U-shaped with subequal limbs; the vaginal duct shorter than the limbs.

The anterior portion of the female median region is in the median chamber, but from ganglion xiii posteriorly, the body of the vagina extends into the paramedian chamber.

The prostate glands are a heavy thick cap investing the atrium and extending briefly along the penis sheath. The semitranslucent albumin glands invest the common oviduct, but not the atrium.

Paratype (*Fig.* 1, *C*)

Colour and pattern as in the type, excepting that the supramarginal field is pale, continuous from the velum back to xxvii, and continuous with the venter.

Annulation, as in the type: excepting vii a_3 slightly longer than viii a_1; xxv, b_1 slightly $>b_2<a_2<a_3$; but xxv a_3 distinctly $>$ xxvi a_1a_2.

Alimentary tract, as in type. Teeth poorly defined, minute, about 48, the longest at the medial end 0.017 mm tall, about 0.010 mm in the middle of the row, the final 10 or 12 granular.

Reproductive system, as in type: excepting the ejaculatory bulbs are partly folded; the limbs of the vagina, subequal; the length of the vaginal duct: the length of the procurrent limb as 2: 3.

The vaginal duct, opened, showed an organized muscular wall lined with an epithelium thrown into longitudinal rugae, and a relatively large lumen.

Other Material (*Fig.* 2, *G, H*)

Two specimens, 42.0 mm and 21.0 mm long from a creek between Bathurst and Orange, N.S.W. Coll. W. H. Dawbin, 1st March, 1967.

a. 42.0 mm. Colour and pattern as in type, excepting margin pale in both supramarginal and submarginal fields, continuous from the velum to xxvii, and continuous with the venter.

Annulation exhibiting a tendency to couplets on 5-annulate somites, b_1 and b_2, b_5 and b_6; vii a_3 distinctly $>$ viii a_1; xxv, $b_1 = b_2<a_2<a_3$; xxv a_3 very slightly $<$ xxvi a_1a_2.

Alimentary tract, as in type.

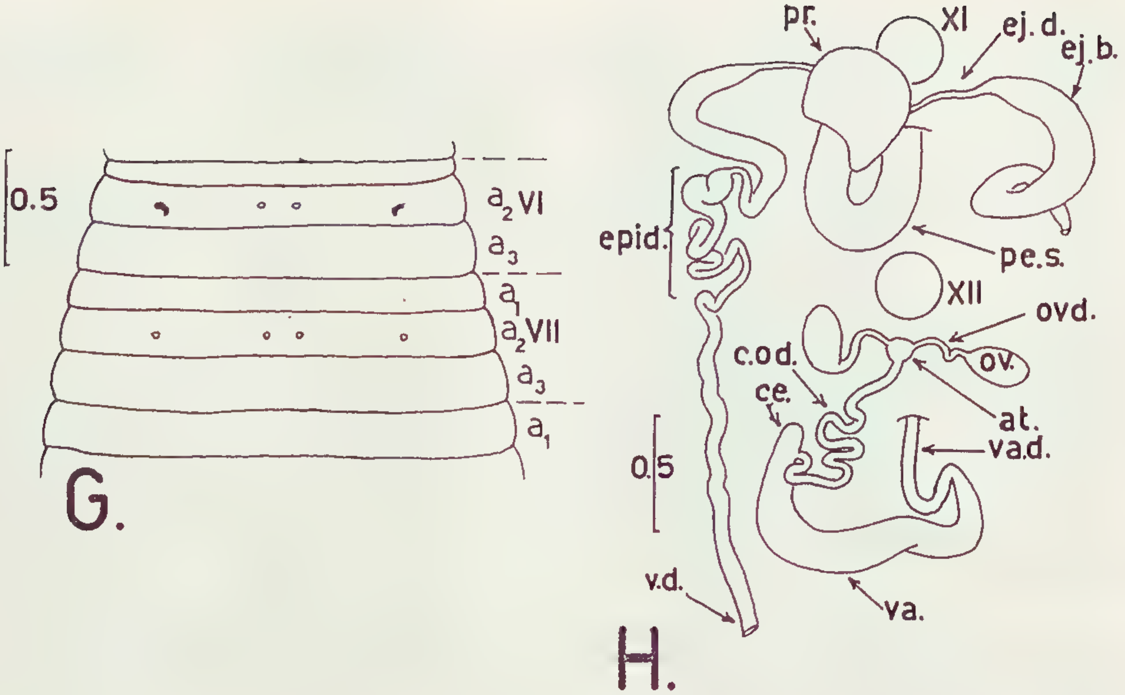


Figure 2, G, H.—*Bassianobdella fusca*, 21.0 mm long. G, dorsal annulation, somites vi, vii, and viii a_1. H, anterior region male paired ducts; male median region; female reproductive system. For abbreviations see figure 1.

Reproductive system. Fully mature male. Anterior portion of epididymis grossly swollen, forming a large convoluted compact globoid mass in and of the length of xii and nearly as wide as long; behind this a small, short, narrowly tubular folded portion. Female median region, as in type, excepting the procurrent limb tapering very gradually, becoming progressively muscular as a short and well-characterized vaginal duct.

b. 21.0 mm. Colour, preserved in alcohol, as in the type, excepting: median dorsal band, greyish-brown. Pattern, as in type, excepting: supramarginal field pale, continuous with the submarginal field and the venter; paramedian band slightly darker laterally than medially.

Annulation, as in type, excepting: interannular furrows not equivalent posterior to ix, with commonly b_1/b_2 and b_5/b_6 much shallower than b_2/a_2, a_2/b_5, and intersomitals, so that somital limits are recognizable and in the middle group there are obvious couplets on either side of a_2 on both the dorsum and the venter, with a_2 distinctly recognizable as longer than b_1 and b_2 in the anterior somites of the middle group; vii a_3 distinctly $>$ viii a_1; xxv, $b_1 < b_2$ slightly $< a_2 < a_3$; xxv $a_3 >$ xxvi $a_1 a_2$.

Alimentary tract, as in type. A pair of well-formed small caeca in the anterior position on all crop compartments, in addition to the primary paired caeca in the median position, is misleading. The thin wall of the crop enables the internal rugae to be followed, and the manner in which the rugae continue into the anterior "caeca" indicates that these are temporary.

Reproductive system. Immature. Exhibiting only early indications of functional differentiation on the anterior region of the paired male duct where the epididymis is little folded and clearly divided into a posterior narrowly tubular portion leading into a more widely tubular anterior portion.

The specimen demonstrates that the elongate cylindroid form of the ejaculatory bulbs and of the U-shaped vagina are established before functional differentiation, and are primary morphological forms. It illustrates quite clearly that the body of the vagina is formed on the elbow and posterior portions of the primary loop, with the common oviduct and vaginal duct completing the recurrent and procurrent limbs of the loop. Comparison of the relative lengths of common oviduct and vagina in this immature specimen, with the condition in the adult, shows that growth in functional differentiation is at a higher level on the muscular portions of the primary loop than on the non-muscular common oviduct, as was anticipated earlier from a study of the comparative morphology of the male and female median regions (Richardson, 1969a). In this specimen, the common oviduct approximates to three-quarters of the full length of the vagina. In the adult, the common oviduct is less than half the length of the procurrent limb. The caecate condition is shown as an early morphological achievement.

ACKNOWLEDGMENTS

I express my appreciation for assistance to Dr W. H. Dawbin, University of Sydney, for specimens; to Miss E. Pope, of the Australian Museum, who has been helpful in many ways; to the Librarian, University of New England, for assistance with literature; to Professor Marvin C. Meyer, University of Maine, for help with difficult literature; and to the Science and Industry Endowment Fund for the loan of microscopic and other equipment.

LITERATURE CITED

Blanchard, R., 1897. Hirudinées des Indes néerlandaises. Weber, *Zool. Ergebn. in Niederl. Oostindien.*, 4: 332–356.

Johansson, L., 1911. Hirudinea. In *Die Fauna Südwest-Australiens.*, 3, L.12: 407–431.

Moore, J. P., 1900. A description of *Microbdella biannulata* with especial regard to the constitution of the leech somite. *Proc. Acad. Nat. Sci. Philadelphia*, 5: 50–73.

———, 1927. Hirudidae. In Harding and Moore, The Fauna of British India including Ceylon and Burma. London. xxxviii + 302.

Moquin-Tandon, A., 1846. Monographie de la famille des Hirudinées. Paris. Ed. 2: 1–448 + Atlas.

Richardson, L. R., 1969 a. A contribution to the systematics of the hirudinid leeches, with description of new families, genera and species. *Acta Zool. Hung.*, xv (1–2): 97–149.

———, 1969 b. The rediscovery of *Hirudo elegans* Grube 1867. *Mem. Queensl. Mus.*, 15 (3): 191–203.

———, 1969 c. On a distinctive new subequatorial Australian quadrannulate land-leech, and related matters. *Aust. Zool.*, 15 (2): 201–213.

———, 1970. *Bassianobdella victoriae* gen. et sp. nov. (Hirudinoidea: Richardsonianidae). *Mem. Nat. Mus. Vic.*, 31: 41–50.

———, 1971 a. *Bassianobdella ingrami* sp. nov. from Tasmania (Hirudinoidea: Richardsonianidae). *Pap. Proc. Roy. Soc. Tasmania*, 105: 113–118.

———, 1971 b. The relationship of the terrestrial jawed sanguivorous g. *Mesobdella* to the Neotropical hirudiniform leeches (Hirudinoidea). *Proc. Linn. Soc. N.S.W.*, 95 (3): 215–220.

———, 1971 c. A new genus and species of Sudan leech formerly confused with *Limnatis nilotica* (Hirudinoidea: F. Hirudinidae s.l.). *Bull. Br. Mus. nat. Hist.* (*Zool.*), 21, 7.

———, 1971 d. *Habeobdella stagni* gen. et sp. nov. from south Western Australia (Hirudinoidea: Richardsonianidae). *Journ. Roy. Soc. W.A.*, 54 (2).

Whitman, C. O., 1886. The leeches of Japan. *Quart. Journ. Micr. Sci.* (*N.S.*), 26: 317–416.

AUSTRALASIAN *PECTINISETA* STEIN, WITH NOTES ON THE GENUS (Diptera, Muscidae)

NATIONAL MUSEUM
28 MAR 1972
OF VICTORIA

By Adrian C. Pont

Department of Entomology, British Museum (Natural History), London

Figures 1–32.

Manuscript received, 9th October, 1970

SYNOPSIS

A key is given to the Indo-Australasian species of *Pectiniseta* Stein. Descriptions are given of the type-species, *pectinata* (Stein), and of the four Australian species, *australis* (Malloch), new comb., *occulta* sp. nov., *similis* sp. nov. and *torresiana* sp. nov. Notes are given on the other two Australasian species. A catalogue of the described species in the genus is given.

INTRODUCTION

The genus *Pectiniseta* was described by Stein (1919: 145) for a species o Coenosiinae with an unusual head-profile, where a sharp angle is formed at the profrons, with a long face and long antennae, and with a pectinate arista in the male sex. The genus has been maintained in subsequent revisionary work by Malloch (1929b), Crosskey (1962) and Snyder (1965), and these authors, particularly Malloch and Crosskey, have emphasized the very close relationship between *Pectiniseta* and *Lispocephala* Pokorny. The characters of the pectinate male arista and the long-plumose female arista, combined with the angular head-profile (figs 1 and 2), are still the principal characters that have been used to define the genus and to differentiate it from *Lispocephala*.

In a recent key to the Oriental genera of Coenosiinae, Crosskey (1962) has included *Pectiniseta*, but he doubted whether it could be distinguished satisfactorily from *Lispocephala* and maintained as a good genus. In my opinion, not only *Pectiniseta* but also *Parvisquama* Malloch can be maintained as distinct genera, closely related to but distinct from *Lispocephala*. It is possible that new species of *Lispocephala* will be discovered with a long-plumose arista that will be indistinguishable from *Pectiniseta* in the female sex: in this case *Pectiniseta* might be used as a name for a subgeneric segregate within *Lispocephala*. Using the characters of the head and of the female ovipositor discussed below, I am continuing to treat *Pectiniseta* as a genus.

Location of Specimens

The following abbreviations are used below to indicate the institutes in which material is located:

ANIC	Australian National Insect Collection, CSIRO, Canberra.
Aust. Mus.	The Australian Museum, Sydney.
BMNH	British Museum (National History), London.
Cop.	University Zoological Museum, Copenhagen.
NMV	National Museum of Victoria, Melbourne.
ZMA	Zoölogisch Museum der Universiteit van Amsterdam.
ZMB	Zoologisches Museum der Humboldt-Universität zu Berlin.

Genus **Pectiniseta** Stein

Pectiniseta Stein, 1919: 96, 145. Type-species: *Caricea prominens* Stein, 1910 (= *Coenosia pectinata* Stein, 1900), by monotypy.

Pectiniseta Stein; Malloch, 1928: 315; Malloch, 1929b: 163; Malloch, 1929c: 326; Séguy, 1937: 223, 231, 242; Emden, 1940: 97; Crosskey, 1962: 400; Snyder, 1965: 201, 218; Hennig, 1965: 65.

Pectinaseta (sic) Stein; Snyder, 1953 and 1965 (passim), errore.

Diagnosis

Pectiniseta can be distinguished from the other genera of the Coenosiinae by the long-pectinate arista of the male (fig. 1) and by the long-plumose arista of the female (fig. 2) combined with the presence of 2 *ors* and 1 *p* seta on mid tibia.

Description

Head rather angular in male, with a long face and with antennae inserted high; less angular in female, with face shorter and less receding. Frons dichoptic in both sexes, at middle almost as broad as an eye. Interfrontalia with a large clearly defined frontal triangle which reaches lunula. Ocellar setae strong. Two pairs of reclinate *ors*. Male with third antennal segment long, just over four times as long as broad, pointed at anterior tip, in frontal view reaching epistoma; female with this segment shorter and normal, a little over three times as long as broad, not pointed at tip, but reaching epistoma. Male with arista pectinate, with a few tiny hairs on apical two-thirds below, but with long regular hairs on most of length above, the longest of which are about one-third length of third antennal segment; female with arista long-plumose, not pectinate except in *fulvithorax* which is pectinate as in the male, the longest plumosity as long as length of third antennal segment. Male with face long and strongly receding, in lateral view face about one and a half times as long as frons (measured from vibrissa to profrons to anterior ocellus). Mentum of proboscis glossy. *Dc* 1 + 3, with a stronger setula before *prst* seta. Anterior *ia* strong. Three *stpl* setae, the lower one equidistant from the upper two and slightly weaker than anterior one. Scutellum with the apical and sub-basal lateral setae strong. Mid femur with 0 *a* and 1 *p* preapical seta. Mid tibia without submedian setae except for 1 *p* at basal two-fifths. Hind femur with 1 *d* preapical seta, in addition to the *ad*. Hind tibia with 2 *ad* and 2 *pd* setae. Lower squama projecting well beyond lower one. Sternite 1 bare.

In the genera *Pectiniseta*, *Lispocephala* and *Parvisquama* the aedeagus with its associated structures is very similar, but there is considerable diversity in the ovipositors. In *Pectiniseta* (figs 4–6), the ovipositor is short. Segment 6 has a normally developed tergite and sternite. Segments 7 and 8 are fused: tergite 7 + 8 extends right round the segment, like a ring, and is even fused ventrally, whilst sternite 7 + 8 has been displaced posteriorly and is divided longitudinally into two small plates. The apical sternite is normal, triangular in shape, the apical tergite is absent, and the cerci are large. The spermathecae (fig. 7) are large. In species of *Lispocephala* dissected for comparison, the ovipositor is similarly short. Segments 7 and 8 are distinct and not fused. Segments 6 and 7 have the tergites extending right round the segments, ring-like, and fused ventrally, but unlike *Pectiniseta* they are divided dorsally along the mid-line; these segments have no sternites. Tergite 8 is present, and sternite 8 is present as a single plate though deeply cleft medially. The apical sternite is narrow and boomerang-shaped, the apical tergite is absent, and the cerci are small. The spermathecae are very large. *Parvisquama ciliata* Malloch has a longer slimmer ovipositor with small cerci and spermathecae. There is very little sclerotization: tergite 6 consists of a pair of longitudinal strut-like sclerites and sternite 6 is minute and round. Segments 7 and 8 are fused: tergite 7 + 8 is round with 2 anterior projections, sternite 7 + 8 is absent. The apical tergite is present but minute, and the apical sternite normal and oval.

Key to Indo-Australasian Species of Pectiniseta

1. Thorax entirely yellow in ground-colour. Antennae and coxae wholly clear yellow. Parafacialia and genae yellow in ground-colour. Scutellum with only about 3 discal setulae, near tip. Palpi entirely yellow .... *fulvithorax* Malloch

— Thorax black in ground-colour. At least basal two antennal segments partly infuscated. At least mid and hind coxae with some dark shadows. Parafacialia and genae black in ground-colour. Scutellum with more discal setulae, at most with basal third bare. Palpi dark at base 2

2. Femora yellow, but the tips sometimes brownish and the fore femur sometimes more extensively darkened in the female. Fore coxa clear yellow, mid and hind coxae partly to mainly yellow 3

— Femora dark brown, only the tips yellow. Coxae usually wholly dark, rarely partially paler at tips 5

3. Upper *ori* weaker, vestigial and hair-like to absent. ♂: fore femur with only the apical 1–2 *pv* setae strong, the rest of the *pv* setae fine and shorter than femoral depth (fig. 8); 5th sternite with the apical part very long and with a row of long setae in addition to the ground-setulae (figs 17 and 18). ♀: fore femur with the *pv* ground-setulae among the setae comparatively long, fine and erect, and those on the *av* surface fine and semi-decumbent .... *similis* nov.

— Upper *ori* stronger, half or more than half as long as lower *ori*. ♂: fore femur with the setae of the *pv* row of uniform length and strength (as in *pectinata* (Stein), fig. 9); 5th sternite with the apical part short and covered with short fine hairs only (figs 14 and 20). ♀: fore femur without erect *pv* ground-setulae among the setae, the setulae all normal and short, and those on the *av* surface stronger and more spine-like in basal half 4

4. ♂: 5th sternite with an indentation in lateral view (fig. 16) and with the setulae on the inner margins of the lobes confined to the posterior part of the sternite (fig. 22); cercal plate broader (fig. 32). ♀: indistinguishable from that of *australis* (Malloch) .... *torresiana* nov.

— ♂: 5th sternite simple in outline in lateral view (fig. 14) and with the lobes almost entirely covered with setulae along inner margins (fig. 20); cercal plate narrower (fig. 31). ♀: indistinguishable from that of *torresiana* sp. nov. .... *australis* (Malloch)

5. ♂: 5th sternite bearing only hairs, which are not or hardly longer than that part of the sternite on which they are situated (figs 10–12 and 21–21a); fore femur with the setae of the *pv* row of uniform length and strength (fig. 9). (Upper *ori* stronger, half or more than half as long as lower *ori*. ♀: indistinguishable from that of *societas* Malloch) .... *pectinata* (Stein)

— ♂: 5th sternite bearing setae in addition to hairs, most of which are much longer than that part of the sternite on which they are situated 6

6. Upper *ori* stronger, half or more than half as long as lower *ori*. ♂: 5th sternite with the setae confined to a tuft on inner edge, directed at right-angles away from the sternite (figs. 13 and 23); fore femur with the setae of the *pv* row of uniform length and strength [as in *pectinata* (Stein), fig. 9]. (♀: indistinguisable from that of *pectinata* (Stein).) .... *societas* Malloch

— Upper *ori* weaker, fine and rudimentary, less than half as long as lower *ori*. ♂: 5th sternite with longer and more scattered setae situated along the outer edge, directed towards the tip of the sternite (figs 15–15a and 19); fore femur with only the apical 1–2 *pv* setae strong, the rest of the *pv* setae fine and shorter than femoral depth (as in *similis* sp. nov., fig. 8) .... *occulta* nov.

Pectiniseta pectinata (Stein)

(Figs 1–7, 9–12, 21–21a, 24–27)

Coenosia pectinata Stein, 1900: 147. Holotype ♂, NEW GUINEA: Friedrich Wilhelmshafen (= Madang). Destroyed; formerly in the Hungarian Natural History Museum, Budapest [see Pont, 1969: 87].

Caricea prominens Stein, 1910: 152. Syntypes, SOCOTRA ISLAND. Lost; formerly in the Zoological Museum of the Humbolt University, Berlin [see note below]. Synonymy by Malloch, 1929b: 163.

Coenosia pallitarsis Stein, 1920: 63. Lectotype ♀, JAVA: Batavia, Moeara Angkee. In the University Zoological Museum, Amsterdam [designation by Pont, 1970: 98] Synonymy by Pont, 1970: 98.

Pectiniseta prominens (Stein) Malloch, 1928: 315; Malloch, 1929b: 163; Malloch, 1929c: 328; Hennig, 1941: 209; Snyder, 1965: 218, figs. 20b–c.

Lispocephala proxima Malloch, 1929a: 393. Holotype ♀, BURU ISLAND. In the University Zoological Museum, Amsterdam [revid. Lee, Crust and Sabrosky, 1956: 331; Pont, 1970: 100]. Synonymy by Pont, 1970: 100.

In the above bibliography, the catalogue references of Stein (1919) and Séguy (1937) have been omitted.

Although the holotype of *pectinata* has been destroyed, Stein's description fits the present species perfectly. In addition, it is the only species of the genus known from New Guinea.

The synonymy of *pectinata* and *prominens* was first suggested by Malloch (1929b: 163), but this synonymy has been followed neither by Malloch himself (1929c) nor by other authors (Séguy, 1937; Snyder, 1965).

Stein described *prominens* from 2 males and 4 females collected on Socotra Island by Simony, which should be preserved in the Zoological Museum of the Humboldt-University, Berlin. None of the original material could be located, and Dr Schumann wrote to me (letter of 19th August, 1969): "Die Art *Pectiniseta prominens* konnte ich ebenfalls in unserer Sammlung nicht finden. Hinter dem Etikett sind zwar Einstiche von Nadeln zu entdecken, jedoch fehlen jegliche Fliegen."

♂. Head: Ground-colour black. Parafrontalia, frontal triangle and occiput densely grey to yellowish-grey pruinose; parafacialia, face and genae lighter grey pruinose. Interfrontalia black, matt from almost all points of view. Eyes bare. Frons broadening uniformly from vertex to lunula. Vertical setae strong; *pvt* short, fine. Post-ocular setulae short, uniform, with scattered setulae below the upper row. Two pairs of inclinate *ori*, the lower one strongest, without interstitials; upper *ors* strongest and closer to the lower one than to vertical; parafrontalia with 3–5 short setulae outside *ori*, otherwise bare. Parafrontalia moderate, at middle of frons a parafrontale equal to twice diameter of anterior ocellus and one-third width of interfrontalia at this point. First and second antennal segments dark, second yellow at tip; third segment orange-yellow to brownish. Parafacialia linear almost throughout, mostly hidden by the eye in profile. In lateral view, vibrissal angle well behind level of profrons. Genae very slender; the depth below lowest eye-margin well under half width of third antennal segment. Vibrissae long and strong; peristomal setae quite long and sparse. Mentum of proboscis dark brown. Palpi slim, yellow, brown at base.

Thorax: Ground-colour black. Mesonotum grey to yellowish-grey dusted, usually with weak traces of 3 brown vittae, a median (*acr*) one and a pair of paramedian (*dc*) ones; the median one sometimes very distinct, sometimes all three very distinct. Pleura and scutellum dusted as mesonotum, the latter dark on sides. Anterior spiracle yellowish to brownish. *Acr* in 2 rows before suture, in 3–4 rows behind. Inner *h* short, half or less than half as long as outer one. Posterior *ph* one-third longer than anterior one. Two propleural and 2 prostigmatal setae, without ground-setulae. Disc of scutellum often bare on basal third, with up to 15 setulae.

Legs: Trochanters, knees, tibiae and tarsi yellow; coxae and femora dark brown, the coxae sometimes partially pale. Fore femur with a row of about 6 *pv* setae, of uniform length and strength. Fore tibia without submedian setae. Mid femur without *av* setae, with a few short *pv* in basal half; 1 *a* at basal two-fifths. Hind femur with 1 *pv* seta just before middle, and sometimes with a few more short *pv*, and 3–4 moderate sparsely placed *av* setae; *ad* row complete. Hind tibia with 2 short *pd*, at basal fifth and at middle; 2 *ad* opposite them, the apical one strongest; 1 short *av*, just beyond middle.

Wings: Virtually clear, the veins yellow. Epaulet brownish, basicosta yellow to brown. Costal spine inconspicuous. Small cross-vein below or slightly apicad of the point where vein 1 enters costa, at or just beyond middle of discal cell. Hind cross-vein straight, upright, slightly longer to slightly shorter than the apical section of vein 5. Veins 3 and 4 subparallel towards wing-margin. Squamae white, halteres yellow.

Abdomen: Short, cylindrical Tergite 1 + 2 and the sides of tergite 3 yellow, tergites 3 and 4 with pale incisures; otherwise dark. In posterior view, tergites 3–5 and the genital tergites densely grey dusted, tergite 1 + 2 appearing undusted except on posterior margin. Tergites 3–5 with black undusted paramedian spots, those on tergites 3 and 4 large and separated by a black undusted median vitta, those on tergite 5 small and confined to anterior half of tergite; sometimes those on tergite 5 also large and separated by a median vitta, and tergite 1 + 2 with a dark median spot. Sides of tergites dusted, except for the pale parts, tergites 3 and 4 with broad dark-brown undusted spots. Genital segments without spots. Tergites 3–5 each with a strong lateral discal seta, placed just outside or on the edge of the black spots, otherwise without well-developed setae except for (usually) a strongish pair of paramedian marginals on tergite 4.

Measurements: Length of body, 3.0–3.5 mm. Length of wing, 2.5–3.0 mm.

♀. Differs from the male as follows. Head: Differences as given in the generic description. Legs: Femora pale basally in two specimens. Mid femur with the *pv* setae longer. Hind femur usually with 2 long *pv* setae and with up to 5 short *av*. Hind tibia with the *ad* setae longer and stronger, and the *pd* either longer or shorter. Abdomen: Short and pointed, not cylindrical. Markings as in male, but spots on tergites 3 and 4 rather smaller. Tergite 1 + 2 with some dust posteriorly. Setae as in male, but rather weaker, the laterals on tergite 3 usually absent. Measurements: Length of body, 3.5–4.0 mm. Length of wing, 3.0–3.5 mm.

In this species, the cercal plate of the male hypopygium (fig. 27) is most like that of *societas* and *torresiana:* it is broader and more densely bristled than in *occulta, australis* and *similis.*

The male 5th sternite is unlike that of any other species except for *australis* and *torresiana* in that it is entirely haired and without setae. The shape, in profile, although slightly variable (figs 10–12), is also consistently different in ground-plan from the other species except for *torresiana*: after the median ventral notch, the sternite is directed slightly ventrad again before running out to the tip. There is some slight geographic variation in shape and in distribution of the ground-hairs. But it should be borne in mind that many of the hairs are on the internal face of the sternite, and so any difference in the angle of inclination of the sternite during observation will produce apparent differences in structure and ciliation. Thus fig. 21a is of a sternite rather flattened beneath a cover-slip and fig. 21 is of a sternite floating in creosote.

Despite the similarities in genital structure between this species and *torresiana*, *pectinata* can be distinguished immediately by the dark-brown femora.

Material examined.—India: Silchar, Cachar, 14.ii.1911 (1 ♂, BMNH), C. B. Antram. Ceylon: Trincomali, Hot Wells, 27.vii.1890 (1 ♂, 1 ♀, BMNH), J. W. Yerbury. Malaya: Kedah Peak, 3,000 feet, 13.iii.1928 (1 ♀, BMNH), H. M. Pendlebury; Kedah Peak, 3,300 feet, 19.iii.1928 (1 ♂, BMNH), H. M. Pendlebury. Sabah: Mt. Kinabalu, Mesilau, 14.ii.1964 (3 ♀, BMNH), J. Smart. Philippines: Tawi Tawi, Tarawakan, north of Batu Batu, caught in Malaise-traps, 4–14.xi.1961 (5 ♀, 1 BMNH and 4 Cop.), Noona Dan Exp.; Balabac, Dalawan Bay, caught in Malaise-traps, 13.x.1961 (1 ♀, Cop.), Noona Dan Exp. Java: Batavia, Moeara Angkee, iv.1908 (♀ lectotype of *pallitarsis* Stein, ZMA), E. Jacobson. Buru Is.: Station 1, 13.xii.1921 (♀ holotype of *proxima* Malloch, ZMA), L. J. Toxopeus. New Guinea: Papua, Central District, Gaile Forest, 28 miles SE of Port Moresby, 1.v.1965 (1 ♂, 1 ♀, BMNH), R. W. Crosskey; Siutmeri, Sepik River, 16.iii.1964 (1 ♂, ANIC), D. H. Colless; Korogo, Sepik River, 8.iii.1964 (1 ♂, ANIC), D. H. Colless. Bismarck Islands: Lavongai, Banatam, 20–26.iii.1962 (1 ♂, 7 ♀, 1 ♀ BMNH and 1 ♂ 6 ♀ Cop.), Noona Dan Exp.; Dyaul, Sumuna, 6.iii.1962 (1 ♀, Cop.), Noona Dan Exp.; Manus, Lorengau, 18.vi.1962 (1 ♀, Cop.), Noona Dan Exp.; Mussau, Boliu, 5.vi.1962 (1 ♂, Cop.), Noona Dan Exp.; Mussau, Talamalaus, 18.i to 9.ii.1962 (7 ♀, 1 BMNH and 6 Cop.), Noona Dan Exp. Solomons, Rennell Is.: Niupani, 22–30.viii.1962 (2 ♂, 3 ♀, 1 ♀ BMNH and 2 ♂ 2 ♀ Cop.), Noona Dan Exp.; Hutuna, 26.iii.1965 and 3.iv.1965 (2 ♀, Cop.), Torben Wolff. Australia, Queensland: Kuranda, 27.xii.1958 (1 ♂, Aust. Mus.), D. K. McAlpine; River Bank Rain Forest, Silkwood, Innisfail, 25.v.1958 (3 ♂, 1 BMNH and 2 Aust. Mus.), D. K. McAlpine; Mulgrave River, 4 miles west of Gordonvale, 29.xii.1958 (3 ♂, 1 BMNH and 2 Aust. Mus.) and 4.i.1959 (1 ♀, Aust. Mus.), D. K. McAlpine; St. Helens Creek, Mackay District, 18.xii.1961 (2 ♀, BMNH and Aust. Mus.), D. K. McAlpine; Mulgrave River, 4 miles west of Gordonvale, 1.i.1967 (1 ♂, Aust. Mus.), 2.i.1967 (1 ♀, Aust. Mus.) and 12.i.1967 (1 ♂, Aust. Mus.), D. K. McAlpine and G. Holloway; 2 miles north of Tully River Bridge, Cardstone-Ravenshoe Road, 16.i.1967 (1 ♂, 1 ♀, Aust. Mus.) and 17.i.1967 (3 ♀, 1 BMNH and 2 Aust. Mus.), D. K. McAlpine and G. A. Holloway; The Intake, via Redlynch, 30.xii.1866 (2 ♂, 3 ♀, 1 ♂, 1♀ BMNH and 1♂ 2 ♀ Aust. Mus.), D. K. McAlpine and G. Holloway; Earl Hill, north of Cairns, 8.v.1967 (6 ♂, 3♀, 1 ♂ 2 ♀ BMNH and 5 ♂ 1 ♀ ANIC) and 11.v.1967 (1 ♂, BMNH), D. H. Colless; Bramston Beach, near Innisfail, open savannah, 30.iv.1967 (1 ♂, 1 ♀, ANIC), D. H. Colless; Bamboo Creek, near Miallo, north of Mossman, 25.iv.1967 (3 ♂, 1 BMNH and 2 ANIC), D. H. Colless; Kuranda Range State Forest, 7–8 miles Black Mt. Road, 20.iv.1967 (1 ♂, ANIC), D. H. Colless; Kuranda Range State Forest, 20.iv.1967 (2 ♂, ANIC), D. H. Colless; Yungaburra (State Forest 452), 29.iv.1967 (1 ♀, ANIC), D. H. Colless; Forest Road, near Ingham, 20.iii.1961 (1 ♀, ANIC), R. Straatman; 22 miles SW Ingham, 5.vi.1961 (1 ♀, ANIC), R. Straatman.

In addition to the localities given above, *pectinata* has been recorded from East Africa (Emden, 1940), Socotra Island (type-locality of *prominens* Stein), Formosa (Malloch, 1928; Hennig, 1941), Samoa (Malloch, 1929c), South Mariana Islands (Snyder, 1965) and Caroline Islands (Snyder, 1965).

Pectiniseta similis sp. nov.

(Figs 8, 17–18, 30)

♂. Head: Ground-colour black. Parafrontalia, frontal triangle and occiput densely grey to yellowish-grey pruinose; parafacialia, face and genae lighter grey pruinose. Interfrontalia black, matt from almost all points of view. Eyes bare. Frons broadening uniformly from vertex to lunula. Vertical setae strong; *pvt* short, fine. Post-ocular setulae short, uniform, with scattered setulae below the upper row. One pair of inclinate *ori*, at lunula, sometimes with a short, fine auxiliary pair above which is always less than half as long as lower *ori;* upper *ors* strongest and closer to the lower one than to vertical; parafrontalia with 2–4 short setulae outside *ori*, otherwise bare. Parafrontalia moderate, at middle of frons a parafrontale equal to twice diameter of anterior ocellus and one-third of interfrontalia at this point. First and second antennal segments brown, the second yellow at tip; third segment orange-yellow, usually smoky at tip. Parafacialia linear almost throughout, mostly hidden by the eye in profile. In lateral view, vibrissal angle well behind level of profrons. Genae very slender; the depth below lowest eye-margin well under half width of third antennal segment. Vibrissae long and strong. Mentum of proboscis dark brown. Palpi slim, yellow, brown at extreme base.

Thorax: Ground-colour black. Mesonotum grey dusted, partially and weakly tinged with yellow, without vittae but sometimes with very faint weak traces of vittae along the *dc* rows. Pleura and scutellum dusted as mesonotum, the latter dark on sides. Anterior spiracle dirty yellowish. *Acr* in 2 rows before suture, in 3–4 rows behind. Inner *h* short, half or less than half as long as outer one. Posterior *ph* one-third longer than anterior one. Two propleural and 2 prostigmatal setae, without ground-setulae. Disc of scutellum mainly setulose, with up to 12 setulae.

Legs: Yellow; mid and hind coxae partly darkened, and mid and hind femora with weak brownish rings at tips. Fore femur with a row of about 6–8 *pv* setae, only the apical 1–2 setae strong, all the others fine and shorter than femoral depth. Fore tibia without submedian setae. Mid femur without *av* or *pv* setae, but some of the basal setulae longer and more erect; 1 *a* at basal two-fifths. Hind femur with 1 moderate *pv* seta just before middle, sometimes with a few other short *pv*; 1 strong preapical *av* seta, and a series of 4–5 short fine *av* setae in basal half; *ad* row complete. Hind tibia with 2 short *pd*, at basal quarter and at middle; 2 *ad* opposite them, the apical one strongest; 1 short *av*, just beyond middle.

Wings: Virtually clear, the veins yellow. Epaulet and basicosta yellow or brown. Costal spine inconspicuous. Small cross-vein below the point where vein 1 enters costa, just beyond middle of discal cell. Hind cross-vein straight, upright, slightly shorter than the apical section of vein 5. Veins 3 and 4 subparallel towards wing-margin. Squamae white, halteres yellow.

Abdomen: Short, cylindrical. Tergite 1 + 2 and sides of tergites 3 and 4 yellow, tergites 3 and 4 with pale incisures; otherwise dark. In posterior view, tergites 3–5 and the genital tergites densely grey dusted, tergite 1 + 2 undusted except posteriorly. Tergites 3–5 with black undusted paramedian spots, those on tergites 3 and 4 large and separated by a weakly dusted dark median vitta, those on tergite 5 small and confined to anterior half of tergite. Sides of tergites dusted, except for the pale parts, tergites 3 and 4 with dark brown virtually undusted spots. Genital segments without spots. Tergites 3–5 each with a strong lateral discal seta placed just outside or on the margins of the black spots, otherwise without well-developed setae; sometimes tergites 4 and 5 each with a pair of moderate median marginal setae.

Measurements: Length of body, 3.0–3.5 mm. Length of wing, 2.5–3.0 mm.

♀. Differs from the male as follows: Head: Differences as given in the generic description. Thorax: Rather more distinct traces of brownish vittae present, a median (*acr*) one and a pair of paramedian (*dc*) ones. Legs: Mid and hind femora often rather infuscated in apical quarter to third. Fore femur with the *pv* row developed normally, the setae uniform; several long *pv* setulae among the setae in basal half or more. Mid femur with 3–4 short *pv* setae in basal third. Hind femur with 2 strong *pv* setae around middle. Hind tibia with the *ad* setae much longer and stronger. Abdomen: Short and pointed, not cylindrical. Tergites 3 and 4 not very yellow at sides, tergite 5 pale at tip. Markings as in male, but spots on tergite 5 larger and separated by a dark median vitta. Setae as in male, but tergite 5 with neither lateral discals nor median marginals. Measurements: Length of body, 3.0–3.5 mm. Length of wing, 2.5–3.0 mm.

P. similis can be recognized by the external characters without difficulty. The male 5th sternite is very characteristic: the apical part is greatly elongated and curved, and is longer than in any of the other species. It is covered with more numerous and longer setulae than in any other species. For further discussion, see under *occulta* nov.

The cercal plate of the male genitalia (fig. 30) is most like that of *occulta* and *australis:* it is narrower and more sparsely bristled than in *pectinata*, *societas* and *torresiana*. However, it is more bulbous in the basal part than is *occulta*.

Material examined.—Australia, Queensland: Mulgrave River, 4 miles west of Gordonvale, 15.xii.1961 (♂ holotype, Aust. Mus.), McAlpine and Lossin; Kuranda, 23.xii.1958 (1 ♂ paratype, BMNH) and 24.xii.1958 (1 ♂ paratype, Aust. Mus.), D. K. McAlpine; North Maria Creek, near Silkwood, 14.xii.1961 (2 ♀ paratypes, Aust. Mus.), D. K. McAlpine; 7–14 miles west of Herberton, via Watsonville, 1.v.1967 (1 ♂ paratype, ANIC), D. H. Colless; Bramston Beach, near Innisfail, open savannah, 30.iv.1967 (1 ♀ paratype, ANIC), D. H. Colless; Mopo, near Babinda, 29.xii.1966 (1 ♀ paratype, Aust. Mus), D. K. McAlpine and G. Holloway; W. Burleigh, 4.v.1970 (1 ♀, not a paratype, ANIC), Z. Liepa. Australia, Northern Territory: 48 miles south-west of Daly River, 14.11 S, 130.08 E, 25.viii.1968 (1 ♂ paratype, ANIC), M. Mendum. Australia, New South Wales: Brunswick Heads, 22.v.1966 (1 ♀ paratype, ANIC), Z. Liepa. Australia, Western Australia: Crossing Pool, Millstream, 21.x.1970 (2 ♂, 1 ♀ paratypes, ANIC), D. H. Colless; Millstream, 22.x.1970 (1 ♀ paratype, ANIC), 23.x.1970 (1 ♂, 2 ♀ paratypes, ANIC), 24.x.1970 (1 ♀ paratype, ANIC), and 25.x.1970 (24 ♂, 42 ♀ paratypes, 4 ♂ and 7 ♀, BMNH, 20 ♂ and 35 ♀ ANIC), D. H. Colless.

Pectiniseta occulta sp. nov.

(Figs 15–15a, 19, 28)

♂. Head: Ground-colour black. Parafrontalia, frontal traingle and occiput densely grey to yellowish-grey pruinose; parafacialia, face and genae lighter grey pruinose. Interfrontalia black, matt from almost all points of view. Eyes bare. Frons broadening uniformly from vertex to lunula. Vertical setae strong; *pvt* short, fine. Post-ocular setulae short, uniform, with scattered setulae below the upper row. Two pairs of inclinate *ori*, the lower one strong, the upper one fine and rudimentary, without interstitials; upper *ors* strongest and closer to the lower one than to the vertical; parafrontalia with 2–4 short setulae outside *ori*, otherwise bare. Parafrontalia moderate, at middle of frons a parafrontale equal to twice diameter of anterior ocellus and one-third width of interfrontalia at this point. First and second antennal segments dark brown, second yellow at tip; third segment orange-yellow, sometimes smoky near tip. Parafacialia linear almost throughout, mostly hidden by the eye in profile. In lateral view, vibrissal angle well behind level of profrons. Genae very slender; the depth below lowest eye-margin well under half width of third antennal segment. Vibrissae long and strong; peristomal setae quite long and sparse. Mentum of proboscis dark brown. Palpi slim, brown in basal half or more, yellow at tip.

Thorax: Ground-colour black. Mesonotum grey to yellowish-grey dusted, with weak traces of darker dusted vittae, a median (*acr*) one and a pair of paramedian (*dc*) ones. Pleura and scutellum dusted as mesonotum, the latter dark on sides. Anterior spiracle dirty yellowish. *Acr* in 2 rows before suture, in 3–4 rows behind. Inner *h* half or less than half as long as outer one. Posterior *ph* one-third longer than anterior one. Two propleural and 2 prostigmatal setae, without ground-setulae. Disc of scutellum usually bare on basal third, with 10–12 setulae.

Legs: Trochanters, knees, tibiae and tarsi yellow; coxae and femora dark brown. Fore femur with a row of 6–7 *pv* setae, only the apical seta strong, all the others fine and shorter than femoral depth. Fore tibia without submedian setae. Mid femur without *av* or *pv* setae, with only a few longer *pv* ground-setulae in basal third; 1 *a* at basal two-fifths. Hind femur with 1 *pv* seta just before middle, and 1–2 other short *pv; av* surface with 1 strong preapical seta and 1–2 other setae; *ad* row complete. Hind tibia with 2 short *pd*, at basal fifth and at middle; 2 *ad* opposite them, the apical one strongest; 1 short *av*, just beyond middle.

Wings: Virtually clear, the veins yellow. Basicosta and epaulet dark brown. Costal spine inconspicuous. Small cross-vein below or slightly apicad of the point where vein 1 enters costa, at or just beyond middle of discal cell. Hind cross-vein straight, upright, slightly shorter than apical section of vein 5. Veins 3 and 4 subparallel towards wing-margin. Squamae white, halteres yellow.

Abdomen: Described from holotype only. Short, cylindrical. Tergite 1 + 2 and lowest edges of tergites 3 and 4 orange-yellow; tergites 3 and 4 with pale incisures; otherwise dark. In posterior view, tergites 3–5 and the genital tergites densely grey dusted, posterior part of tergite 1 + 2 also dusted. Tergites 3 and 4 with large black undusted paramedian spots, separated by a black undusted median vitta; tergite 5 partly withdrawn, but large black spots and weak traces of a median vitta visible. Sides of tergites dusted, except for the pale parts, tergites 3 and 4 with broad dark brown undusted spots. Genital segments without spots. Tergites 3–5 each with a pair of strong lateral discal setae, placed on the edge of or just outside the black spots, those on tergite 5 closer to hind-margin; otherwise without well-developed setae.

Measurements: Length of body, 3.0 mm. Length of wing, 2.5 mm.

♀. Differs from the male as follows. Head: Differences as given in the generic description. Thorax: Mesonotal vittae more strongly developed. Legs: Fore femur with the *pv* row developed normally, the setae uniform. Hind femur and hind tibia with the setae longer and stronger, 2 strong *pv* on hind femur. Abdomen: Short and pointed, not cylindrical. Markings as in male, dorsal and lateral spots on tergites 3–5 bold. Setae as in male, but weaker, the lateral discals on tergite 3 absent. Measurements: Length of body, 3.0–3.5 mm. Length of wing, 2.5–3.0 mm.

The cercal plate of the male genitalia (fig. 28) is most like that of *australis* and *similis*: it is narrower and more sparsely bristled than in *pectinata*, *societas* and *torresiana*. It is, however, less markedly swollen in the basal part than are *australis* and *similis*.

The male 5th sternite is very similar to that of *similis*, and these two species are more closely related to each other than to the other four Australasian species. The bristling of the sternite is rather similar in the two species, with long setae along the whole length of the apical part: as the apical part is much shorter in *occulta* than in *similis*, there are fewer setae in that species than in *similis*.

Material examined.—Australia, Queensland: Claudie River near Mt. Lamond, 3.vi.1966 (♂ holotype and 1 ♂ 1 ♀ paratypes, Aust. Mus.) and 31.v.1966 (1 ♂ paratype, BMNH), D. K. McAlpine. Bismarck Islands: Lavongai, Banatam, 21.iii.1962 (1 ♂ paratype, Cop.) and 22.iii.1962 (1 ♀ paratype, Cop.), Noona Dan Exp.

Pectiniseta australis (Malloch) new comb.

(Figs 14, 20, 31)

Lispocephala australis Malloch, 1923: 604. Holotype ♀, AUSTRALIA: Queensland, Burnett River. In the British Museum (Natural History), London (revid. Lee, Crust and Sabrosky, 1956: 309; examined by myself].

Lispocephala australis Malloch; Séguy, 1937: 229.

♂. Head: Ground-colour black. Parafrontalia, frontal triangle and occiput densely grey to yellowish-grey pruinose; parafacialia, face and genae lighter grey pruinose. Interfrontalia black, matt from almost all points of view. Eyes bare. Frons broadening uniformly from vertex to lunula. Vertical setae strong; *pvt* short, fine. Post-ocular setulae short, uniform, with scattered setulae below the upper row. One pair of inclinate *ori*, at lunula, with a second weaker pair above that is just over half as long as lower pair, without any interstitials; upper *ors* strongest and closer to the lower one than to vertical; parafrontalia with 2–4 short setulae outside *ori*, otherwise bare. Parafrontalia moderate, at middle of frons a parafrontale equal to twice diameter of anterior ocellus and one-third of interfrontalia at this point. First and second antennal segments brown, the second yellow at tip; third segment orange-yellow, smoky at tip. Parafacialia linear almost throughout, mostly hidden by the eye in profile. In lateral view, vibrissal angle well behind level of profrons. Genae very slender; the depth below lowest eye-margin well under half width of third antennal segment. Vibrissae long and strong. Mentum of proboscis brown. Palpi slim, yellow, brown at extreme base.

Thorax: Ground-colour black. Mesonotum grey dusted, partially and weakly tinged with yellow, without vittae but sometimes with very faint weak traces of vittae along the *dc* rows. Pleura and scutellum dusted as mesonotum, the latter dark on sides. Anterior spiracle dirty yellowish. *Acr* in 2 rows before suture, in 3–4 rows behind. Inner *h* short, half or less than half as long as outer one. Posterior *ph* one-third longer than anterior one. 2 propleural and 2 prostigmatal setae, without ground-setulae. Disc of scutellum mainly setulose, with up to 12 setulae.

Legs: Yellow; mid and hind coxae partly darkened, and mid and hind femora with small weak brownish rings at tips. Fore femur with a row of 6 *pv* setae, all more or less uniform and subequal to femoral depth. Fore tibia without submedian setae. Mid femur with 3 short fine *pv* setae in basal third, slightly shorter than femoral depth; 1 *a* at basal two-fifths. Hind femur with 1 moderate *pv* near middle, and a few shorter *pv* nearer base; 1 strong preapical *av* seta, and a series of 4–5 short fine *av* setae in basal half; *ad* row complete. Hind tibia with 2 short *pd*, at basal quarter and at middle; 2 *ad* opposite them, the apical one strongest; 1 short *av*, just beyond middle.

Wings: Virtually clear, the veins yellow. Epaulet and basicosta orange-yellow. Costal spine inconspicuous. Small cross-vein below the point where vein 1 enters costa, just beyond middle of discal cell. Hind cross-vein straight, upright, slightly shorter than the apical section of vein 5. Veins 3 and 4 subparallel towards wing-margin. Squamae white, halteres yellow.

Abdomen: Only two males seen, both damp and rubbed. Short and cylindrical. Tergite 1 + 2, tergite 3 except for dark spots, and hind-margin of tergite 4 yellow; sides of posterior tergites more yellow; otherwise dark. Rather damp, but in posterior view with some of the dark areas with visible grey dust. Tergites 3–5 each with a pair of black paramedian spots, these rather small and oval, those on tergites 3 and 4 separated by a dark median spot or vitta. Sides of tergites apparently grey dusted on the dark areas, which are not very extensive, without dark spots. Genital segments without spots. Tergites 3–5 each with a strong lateral discal seta placed just outside or on the margins of the black spots, otherwise without well developed setae except for a pair of median marginals on tergite 4.

Measurements: Length of body, 3.0–3.5 mm. Length of wing, 2.5–3.0 mm.

♀. Differs from the male as follows. Head: Differences as given in the generic description. In addition, upper *ori* stronger, and very distinct, third antennal segment sometimes smoky, and mentum of proboscis dark brown. Thorax: Mesonotum sometimes with more distinct traces of brownish vittae present, a median (*acr*) one and a pair of paramedian (*dc*) ones. Legs: Fore femur with the *pv* setae stronger; *av* surface with a comb-like row of strong almost spine-like setulae in basal half. Mid femur with 2–4 *pv* setae. Hind femur with 2 strong *av* setae in apical half, otherwise as in male. Wings: Epaulet and basicosta orange-brown to yellow to brown. Abdomen: Short and pointed, not cylindrical. Tergite 1 + 2 entirely yellow, tergites 3–5 broadly so on hind-margins; tergite 3 yellow on fore-margin, on dorsal surface and at sides. In posterior view, grey dusted except on the dark spots and on the yellow areas. Tergites 3–5 with the paramedian and median spots darker and bolder; sides of tergites 3 and 4 with weak dark spots. Measurements: Length of body, 3.5–4.0 mm. Length of wing, 3.0–3.5 mm.

The cercal plate of the male genitalia (fig. 31) is most like that of *occulta* and *similis*: it is narrower and more sparesely bristled than in *pectinata*, *societas* and *torresiana*. It is, however, more bulbous in the basal part than is *occulta*.

The male 5th sternite is rather short and simple, unlike that of any species in the genus. The apical part is without any notch or indentation in either dorsal or lateral view, and is covered with only fine setulae few, if any, of which are longer than that part of the sternite on which they are situated.

Material examined.—Australia, Queensland: Burnett River, no date (♀ holotype, BMNH), T. L. Bancroft; 7–14 miles west of Herberton via Watsonville, 1.v.1967 (1 ♂, 1 ♀, ANIC), D. H. Colless; Big Mitchell Creek, Mareeba-Molloy Road, 4.v.1967 (1 ♀, ANIC), D. H. Colless. Australia, Northern Territory: 48 miles southwest of Daly River, 14.11 S, 130.08 E, 5.ix.1968 (1 ♂, ANIC), M. Mendum; 34 miles northwest of Dorisvale HS, 14.13 S, 130.55 E, 14.viii.1968 (1 ♀, ANIC), M. Mendum.

Pectiniseta torresiana sp. nov.

(Figs 16, 22, 32)

♂. Head: Ground-colour black. Parafrontalia, frontal triangle and occiput densely yellowish-grey pruinose; parafacialia, face and genae lighter grey pruinose. Interfrontalia black, matt from almost all points of view. Eyes bare. Frons broadening uniformly from vertex to lunula. Vertical setae strong; *pvt* short, fine. Post-ocular setulae short, uniform, with scattered setulae below the upper row. One pair of inclinate *ori*, at lunula, with a second weaker pair above that is just over half as long as lower pair, without any interstitials; upper *ors* strongest and closer to the lower one than to vertical; parafrontalia with 2–4 short setulae outside *ori*, otherwise bare. Parafrontalia moderate, at middle of frons a parafrontale equal to twice diameter of anterior ocellus and one-third of interfrontalia at this point. First and 2nd antennal segments brown, the 2nd yellow at tip; 3rd segment orange-yellow. Parafacialia linear almost throughout, mostly hidden by the eye in profile. In lateral view, vibrissal angle well behind level of profrons. Genae very slender; the depth below lowest eye-margin well under half width of 3rd antennal segment. Vibrissae long and strong. Mentum of proboscis dark brown. Palpi slim, yellow, brown at base.

Thorax: Ground-colour black. Mesonotum grey to yellowish-grey dusted, without distinct vittae but with very faint weak traces of vittae along the *dc* rows. Pleura and scutellum dusted as mesonotum, the latter dark on sides. Anterior spiracle dirty yellowish. *Acr* in 2 rows before suture, in 3–4 rows behind. Inner *h* short, half or less than half as long as outer one. Posterior *ph* one-third longer than anterior one. Two propleural and 2 prostigmatal setae, without ground-setulae. Disc of scutellum mainly setulose, with up to 10 setulae.

Legs: Yellow; mid and hind coxae mainly dark. Fore femur with a row of 6 *pv* setae, all more or less uniform and subequal to femoral depth. Fore tibia without submedian setae. Mid femur with 2–3 short fine *pv* setae in basal third, slightly shorter than femoral depth; 1 *a* at basal two-fifths. Hind femur with 1 long *pv* at middle, and a few shorter *pv* nearer base; 1 strong preapical *av* seta, and a series of 2–3 shorter setae in basal half; *ad* row complete. Hind tibia with 2 short *pd*, at basal quarter and at middle; 2 *ad* opposite them, the apical one strongest; 1 short *av*, just beyond middle.

Wings: Virtually clear, the veins yellow. Epaulet and basicosta orange-yellow. Costal spine inconspicuous. Small cross-vein below the point where vein 1 enters costa or slightly beyond, just beyond middle of discal cell. Hind cross-vein straight, upright, slightly shorter than apical section of vein 5. Veins 3 and 4 subparallel towards wing-margin. Squamae white, halteres yellow.

Abdomen: Described from the holotype only, in which the tip of the abdomen was damp, prior to maceration. Short and cylindrical. Tergite 1 + 2 mainly and sides of tergites 3 and 4 yellow, and tergites 3 and 4 with pale incisures; otherwise dark. In posterior view, tergites 3–5 densely yellowish-grey dusted, tergite 1 + 2 undusted except posteriorly. Tergites 3–5 with dark-brown to black undusted paramedian spots, those on tergites 3 and 4 large and separated by a weakly dusted dark median vitta, those on tergite 5 small and confined to anterior half of tergite. Sides of tergites thinly dusted, tergites 3 and 4 with dull yellow virtually undusted spots. Genital segments without spots. Tergites 4 and 5 each with a pair of strong lateral discal setae placed on the margin of the dark spots and a weaker pair on tergite 3, otherwise without well developed setae except for a piar of moderate median marginal setae on tergites 4 and 5.

Measurements: Length of body, 3.0 mm. Length of wing, 2.5 mm.

♀. Differs from the male as follows. Head: Differences as given in the generic description. 3rd antennal segment smoky in apical part. Legs: Fore femur rather infuscated in 1 female, mid and hind femora brown at tips in the other. Fore femur with the *pv* setae stronger; *av* surface with a comb-like row of more erect setulae in basal half. Hind tibia with the setae rather longer. Abdomen: Short and pointed, not cylindrical. Tergite 1 + 2 wholly yellow; tergites 3 and 4 with yellow incisures and sides; tergite 5 broadly yellow on hind-margin. Spots on tergite 5 rather larger. Marginal setae rather stronger.

Measurements: Length of body, 3.0 mm. Length of wing, 2.5 mm.

The cercal plate of the male genitalia (fig. 32) is most like that of *societas* and *pectinata:* it is broader and more densely bristled than in the other species, but is, if anything, rather broader but less densely bristled than in either *societas* or *pectinata*.

The male 5th sternite is most like that of *pectinata*, and in lateral view the similarity is most striking (cf. figs 10–12 and 16). Like this species and *australis*, *torresiana* lacks all strong setae but, unlike *australis*, it possesses a preapical indentation in lateral view. In spite of the similarities in genital structure between *torresiana* and *pectinata*, the entirely yellow femora, except for the partially darkened femora of the female, will separate it immediately from *pectinata*.

Material examined.—Australia, Torres Strait: Banks Island, 3.iv.1969 (♂ holotype and 2 ♀ paratypes, NMV), A. Neboiss; Prince of Wales Island, 27–30.v.1969 (1 ♂ paratype, BMNH), A. Neboiss.

Pectiniseta societas Malloch

(Figs 13, 23, 29)

Pectiniseta societas Malloch, 1929c: 326, fig. 1. Holotype ♂, TAHITI. In the British Museum (Natural History), London [revid. Lee, Crust and Sabrosky, 1956: 335; examined by myself].

Pectiniseta societas Malloch; Séguy, 1937: 231.

Of this species I have studied only that part of the type-series present in the BMNH. This consists of the holotype ♂, allotype ♀, and 11 paratypes. Lee, Crust and Sabrosky (l.c.) list the holotype and 12 paratypes as being in the BMNH. Three paratypes, 1 collected by Cheesman and 2 by Tonnoir, are not in the BMNH and were not located by Lee, Crust and Sabrosky.

P. societas is very similar to *pectinata*. It has a dark thorax and dark femora, the upper *ori* is strong and well-developed, and the male has the setae of the *pv* row on fore femur of uniform length and strength. In the male, the 5th sternite is very characteristic (see below). There is some variation, particularly in the female sex. The mesonotum may have more extensive dark markings; the long femoral setae may be more robust; the abdomen is sometimes very dark. The female is indistinguishable from that of *pectinata*.

The cercal plate of the male genitalia (fig. 29) is most like that of *pectinata* and *torresiana*: it is broader and more densely bristled than in *occulta*, *australis* and *similis*.

The male 5th sternite is unique and striking, but clearly closer to that of *occulta* and *similis* than to *pectinata* and *torresiana*, both in shape and setation. It is distinguished above all by the absence of setae except for the tuft on the inner apical edge. The ground-setulae, too, are almost totally absent, and none are visible when the sternite is viewed in profile.

Material examined.—Society Islands: Tahiti, no further locality, 19.vii.1925 (♂ holotype, ♀ allotype and 1 ♀ paratype, BMNH) and 10.iii.1925 (1 ♂ and 1 ♀ paratypes, BMNH), L. E. Cheesman; Tahiti, Lake Vaihiria, 17.vii.1925 (1 ♂ and 1 ♀ paratypes, BMNH) and 18.vii.1925 (1 ♀ paratype, BMNH), L. E. Cheesman; Raiatea, no further locality, 14.v.1925 (1 ♀ paratype, BMNH), 25.v.1925 (3 ♀ paratypes, BMNH) and 26.v.1925 (1 ♀ paratype, BMNH), L. E. Cheesman.

Pectiniseta fulvithorax Malloch

Pectiniseta fulvithorax Malloch, 1929b: 163. Holotype ♀, SAMOA: Savaii, Safune. In the B. P. Bishop Museum, Honolulu [revid. Lee, Crust and Sabrosky, 1956: 318; not examined by me].

Pectiniseta fulvithorax Malloch; Séguy, 1937: 231.

I have seen only one specimen of this species, Malloch's male allotype, which is in the BMNH. The abdomen is missing, as was noted by Malloch, and all the legs are missing, too.

This is a very characteristic species that may be easily recognized by the entirely pale colour of the thorax. The other characters given in the key, taken from the single specimen studied, may prove useful additional diagnostic characters.

Material examined.—SAMOA: Savaii, Safune, 2,000–4,000 feet, rainforest, 8.v.1924 (♂ allotype, BMNH), E. H. Bryan.

Catalogue of the Species of Pectiniseta Stein

australis Malloch, 1923, Proc. Linn. Soc. N.S.W., 48: 604 (*Lispocephala*).
AUSTRALIA: Queensland, Burnett River.
QUEENSLAND, NORTHERN TERRITORY.

equiseta Snyder, 1953, Am. Mus. Novit., 1608: 1, figs. 1–2 (*Pectinaseta* [sic]).
LIBERIA: Robertsport.
LIBERIA.

fulvithorax Malloch, 1929, Ins. Samoa, 6 (3): 163 (*Pectiniseta*).
SAMOA: Savaii, Safune.
SAMOA.

obscura Emden, 1940, Ruwen. Exp. 1934–5, 2 (4): 243 (*Pectiniseta*).
UGANDA: Ruwenzori Mts.
UGANDA.

occulta sp. nov.
AUSTRALIA: Queensland, Claudie River.
PAPUAN SUBREGION.

pectinata Stein, 1900, Természetr. Füz., 23: 147 (*Coenosia*).
NEW GUINEA: Madang (as Friedrich Wilhelmshafen).

prominens Stein in Becker, 1910, Denkschr. Akad. Wiss. Wien (math.-nat. Kl.), 71 (2): 152 (*Caricea*).
SOCOTRA ISLAND.

pallitarsis Stein, 1920, Tijdschr. Ent., 62 [1919], Suppl.: 63 (*Coenosia*).
JAVA: Batavia, Moeara Angkee.

proxima Malloch, 1929, Treubia, 7: 393 (*Lispocephala*).
BURU ISLAND.
E. AFRICA, ORIENTAL AND AUSTRALASIAN REGIONS

similis sp. nov.
AUSTRALIA: Queensland, Mulgrave River.
NORTH AND EAST AUSTRALIA.

societas Malloch, 1929, Ann. Mag. nat. Hist. (10), 4: 326, fig. 1 (*Pectiniseta*).
TAHITI ISLAND.
SOCIETY ISLANDS.

torresiana sp. nov.
TORRES STRAIT: Banks Island.
TORRES STRAIT ISLANDS.

ACKNOWLEDGMENTS

I am very grateful to the following colleagues for their assistance in providing me with material or giving me information on the collections in their care: Dr D. H. Colless, Drs W. N. Ellis, Dr L. Lyneborg, Dr D. K. McAlpine, Dr A. Neboiss, Dr. H. Schumann.

REFERENCES

Becker, T., 1910*. Dipteren aus Südarabien und von der Insel Sokotra. *Denkschr. Akad. Wiss. Wien (math.-nat. Kl.)*, 71 (2): 131–160, 5 figs.

Crosskey, R. W., 1962. A revision of the genus *Pygophora* Schiner (Diptera: Muscidae). *Trans. Zool. Soc. Lond.*, 29 (6): 393–551, 124 figs.

Emden, F. I. van, 1940. Muscidae, B: Coenosiinae. In Ruwenzori Expedition 1934–5, 2 (4): 91–255, 82 figs. London.

Hennig, W., 1941. Verzeichnis der Dipteren von Formosa. *Ent. Beih. Berl.-Dahlem*, 8: 1–239.

——— 1965. Vorarbeiten zu einem phylogenetischen System der Muscidae (Diptera: Cyclorrhapha). *Stuttg. Beitr. Naturk.*, 141: 100 pp., 53 figs.

Lee, D. J., Crust, M., and Sabrosky, C. W., 1956. The Australasian Diptera of J. R. Malloch. *Proc. Linn. Soc. N.S.W.*, 80 (1955): 289–342, pl. XI.

Malloch, J. R., 1923. Notes on Australian Diptera with descriptions. *Proc. Linn. Soc. N.S.W.*, 48: 601–622.

——— 1928. Exotic Muscaridae (Diptera). XXII. *Ann. Mag. nat. Hist.* (10), 2: 307–319.

——— 1929a. Fauna Buruana. Diptera, Fam. Muscidae. *Treubia*, 7: 390–408.

——— 1929b. Muscidae. In Insects of Samoa and other Samoan terrestrial Arthropoda, 6 (3): 151–175. London.

——— 1929c. Exotic Muscaridae (Diptera). XXVIII. *Ann. Mag. nat. Hist.* (10), 4: 322–341, 2 figs.

Pont, A. C., 1969. Notes on the Muscidae of New Guinea (Diptera). III. Species described by Stein in 1900, Természetr. Füz., Volume 23. *Dt. ent. Z.*, 16: 81–90.

——— 1970. The type-material of Oriental and Australasian Muscidae (Diptera) in the Zoological Museum, Amsterdam. *Beaufortia*, 18: 77–111.

Séguy, E., 1937. Muscidae. In Wytsman, P., *Genera Insect.*, 205: 604 pp., 9 plates. Bruxelles.

Snyder, F. M., 1953. Notes and descriptions of some Ethiopian Muscidae (Diptera). *Am. Mus. Novit.*, 1608: 21 pp., 7 figs.

——— 1965. Diptera: Muscidae. In Insects of Micronesia, 13 (6): 119–327, 27 figs., 2 tables. Honolulu.

Stein, P., 1900. Anthomyiden aus Neu-Guinea, gesammelt von Herrn L. Biró. *Természetr. Füz.*, 23: 129–159.

——— 1919. Die Anthomyidengattungen der Welt, analytisch bearbeitet, nebst einem kritisch-systematischen Verzeichnis aller aussereuropäischen Arten. *Arch. Naturgesch.*, 83 A 1 (1917): 85–178, 2 figs.

——— 1920. Anthomyiden aus Java, Sumatra, Waigeoe und Ceram. *Tijdschr. Ent.*, 62 (1919), Suppl.: 47–86.

---

* Date of publication given variously as 1907 and 1931. No date is given in the original journal, but as the manuscript was submitted by Stein on 4th November, 1909, the paper was probably published in 1910, as stated by Séguy (1937). See Emden, 1940: 103, footnote.

EXPLANATION OF FIGURES

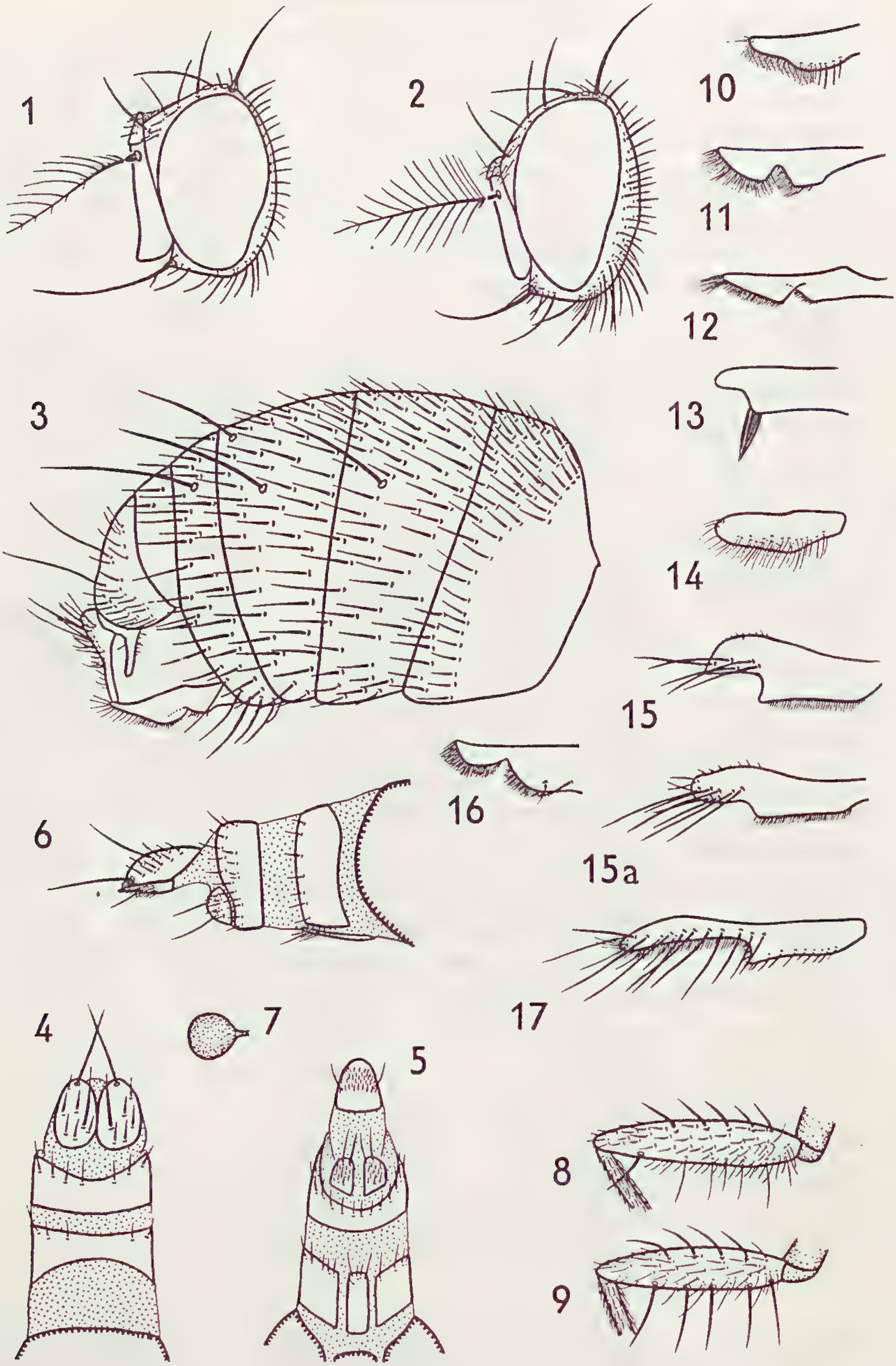
1. *Pectiniseta pectinata*, head of male in lateral view.
2. *P. pectinata*, head of female in lateral view.
3. *P. pectinata*, abdomen of male in lateral view, Malaya.
4. *P. pectinata*, ovipositor of female in dorsal view, Earl Hill, Queensland.
5. *P. pectinata*, ovipositor of female in ventral view, Earl Hill, Queensland.
6. *P. pectinata*, ovipositor of female in lateral view, Earl Hill, Queensland.
7. *P. pectinata*, spermatheca of female, Earl Hill, Queensland.
8. *P. similis*, fore femur of male in posterior view, holotype.
9. *P. pectinata*, fore femur of male in posterior view, Australia.
10. *P. pectinata*, apical part of male 5th sternite in lateral view, Trincomali, Ceylon.
11. *P. pectinata*, apical part of male 5th sternite in lateral view, Niupani, Rennell Island.
12. *P. pectinata*, apical part of male 5th sternite in lateral view, Mulgrave River, Queensland.
13. *P. societas*, apical part of male 5th sternite in lateral view, Lake Vaihiria, Tahiti.
14. *P. australis*, apical part of male 5th sternite in lateral view, Herberton, Queensland.
15. *P. occulta*, apical part of male 5th sternite in lateral view, Claudie River, Queensland.

15a. *P. occulta*, apical part of male 5th sternite in lateral view, Banatam, Lavongai Island.

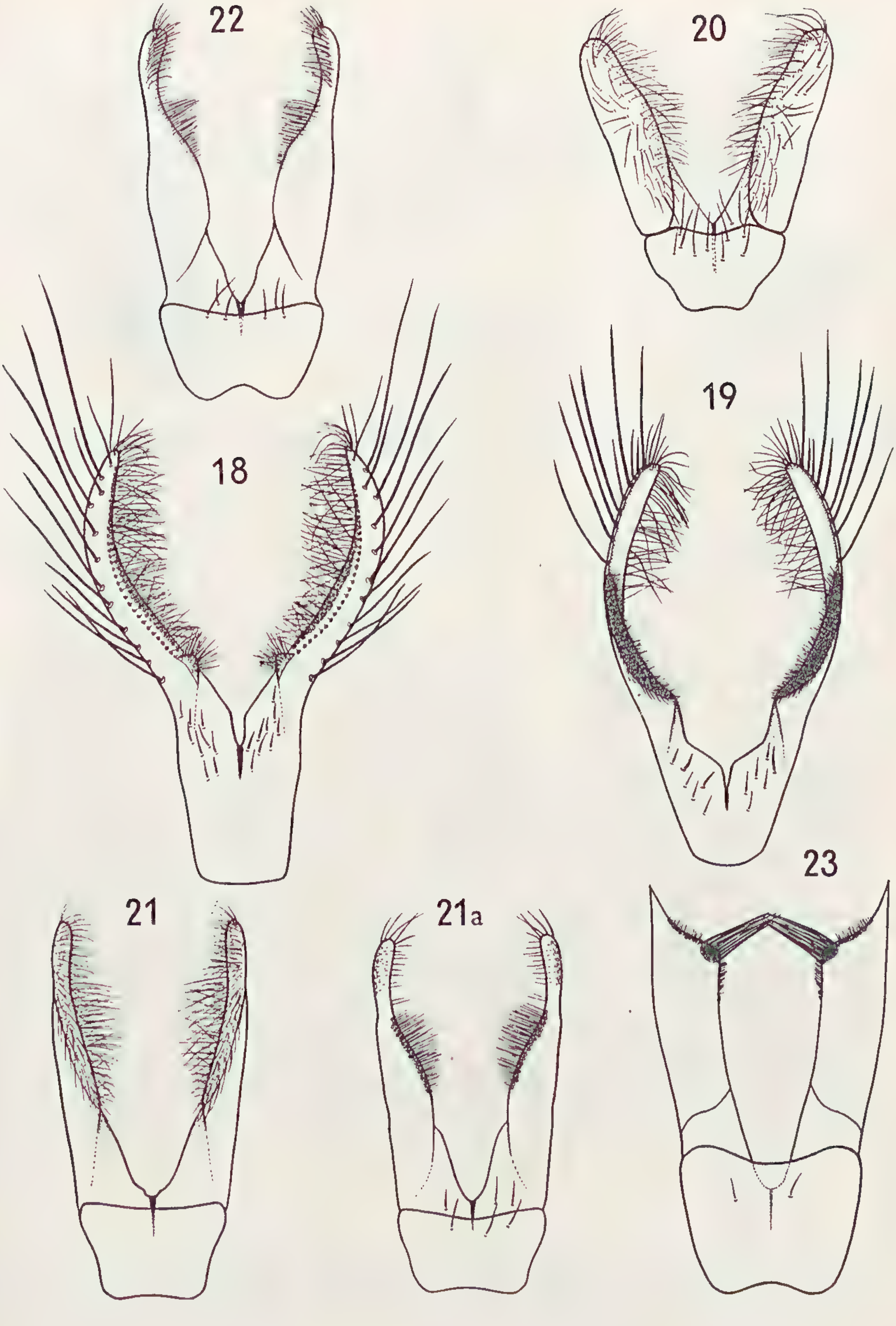
16. *P. torresiana*, apical part of male 5th sternite in lateral view, Torres Strait, Prince of Wales Island.
17. *P. similis*, apical part of male 5th sternite in lateral view, Kuranda, Queensland.
18. *P. similis*, 5th sternite of male in dorsal view, Kuranda, Queensland.
19. *P. occulta*, 5th sternite of male in dorsal view, Claudie River, Queensland.
20. *P. australis*, 5th sternite of male in dorsal view, Herberton, Queensland.
21. *P. pectinata*, 5th sternite of male in dorsal view, Trincomali, Ceylon.

21a. *P. pectinata*, 5th sternite of male in dorsal view, Gaile Forest, Papua.

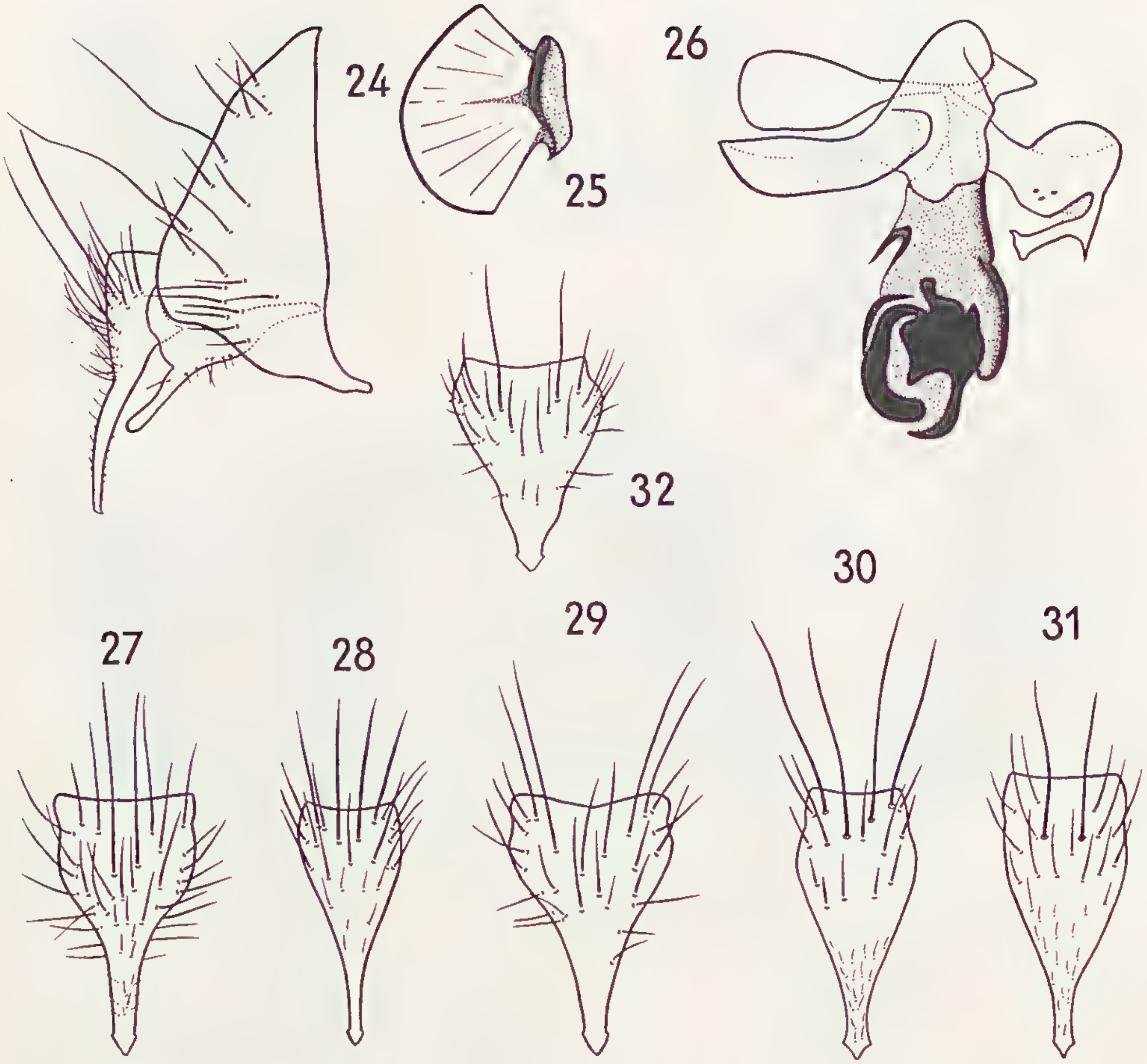
22. *P. torresiana*, 5th sternite of male in dorsal view, Torres Strait, Prince of Wales Island.
23. *P. societas*, 5th sternite of male in dorsal view, Lake Vaihiria, Tahiti.
24. *P. pectinata*, hypopygium of male in lateral view, aedeagus omitted, Kedah Peak, Malaya.
25. *P. pectinata*, sperm pump of male aedeagus, Kedah Peak, Malaya.
26. *P. pectinata*, aedeagus of male with epandrium in lateral view, Earl Hill, Queensland.
27. *P. pectinata*, cercal plate of male in dorsal view, Kedah Peak, Malaya.
28. *P. occulta*, cercal plate of male in dorsal view, Claudie River, Queensland.
29. *P. societas*, cercal plate of male in dorsal view, Lake Vaihiria, Tahiti.
30. *P. similis*, cercal plate of male in dorsal view, Kuranda, Queensland.
31. *P. australis*, cercal plate of male in dorsal view, Herberton, Queensland.
32. *P. torresiana*, cercal plate of male in dorsal view, Torres Strait, Prince of Wales Island.



Figures 1–17



Figures 18–23



Figures 24–32

MAORI GREENSTONE PENDANTS IN THE AUSTRALIAN MUSEUM, SYDNEY

By D. WAYNE ORCHISTON

Department of Anthropology, University of Sydney*

NATIONAL MUSEUM
12 JAN 1973
OF VICTORIA

Plates 22–24. Figs 1–33. Manuscript received 19th November, 1970.

SUMMARY

This paper examines a collection of 93 Maori greenstone pendants in the Australian Museum. Only straight *kuru* are abundant enough for quantitative analysis, but this is first preceded by an examination of the spatial-chronological distribution of the population of this type, changes in it numerically through time, and the characteristics of a random sample. The randomness of the Australian Museum sample of 58 pendants is questioned. A random sample of 70 straight *kuru* in the Auckland Institute and Museum is employed for comparative purposes, and an investigation made of the nature of and interrelationships between various pendant parameters, for the two samples. Other pendant types considered, in addition to straight *kuru* and anomalous forms, are the *kuru kapeu* (5 examples), *hei matau* (1), *koropepe* (4), *pekapeka* (4), *poria* (2), *rei puta* (1), and Triangular Pendant (6). Since none of these types is abundantly represented quantitative studies are impossible, and the spatial-chronological attributes of each are merely examined, and the Australian Museum specimens compared and contrasted with those in other museums.

---

* The research reported in this paper was initiated between December 1968 and January 1969 while the author was employed as a Vacation Assistant in the Anthropology Department at the Museum. The New Zealand fieldwork and museum visits referred to in the text relate to the author's Ph.D. research and were not undertaken specifically for the study reported here.

CONTENTS

Page

INTRODUCTION 163

STRAIGHT *KURU* 166

(1) DESCRIPTIONS OF THE PENDANTS 167

(2) SITE, LOCALITY, AND CHRONOLOGICAL ATTRIBUTIONS 170

(3) THE PROBLEMS OF SAMPLING 171

(4) A RANDOM SAMPLE 177

(5) QUANTITATIVE ANALYSES 177

(6) THE STATUS OF THE *KURU PAPA* 200

OTHER ELONGATED PENDANTS 203

(1) DESCRIPTIONS OF THE PENDANTS 203

(2) DISCUSSION 203

RARER PENDANTS 207

(1) DESCRIPTIONS OF THE PENDANTS 207

(2) DISCUSSION 208

CONCLUSIONS 211

ACKNOWLEDGMENTS 212

REFERENCES 212

TABLES

1. Australian Museum Straight *Kuru* 168
2. Auckland Museum Straight *Kuru* 174
3. Distribution of Cross-sectional Varieties in Two Samples of "M" Pendants 177
4. χ^2 Analysis of B1 "M" Pendants from Sydney and Auckland .. 179
5. Distribution of Distal End Shapes in Two Samples of B1 "M" Pendants 198
6. χ^2 Analysis of Sydney B1 "E-?E" Pendants and B1 "M" Specimens from Sydney and Auckland 198
7. Correlation Coefficients for Plotted Scatter Diagrams 199
8. χ^2 Analysis of B1 and (B2, B1/2, A-B1) Pendants from Auckland .. 199
9. Australian Museum *Kuru Kapeu* 204
10. Australian Museum Anomalous Elongated *Kuru* 206
11. Australian Museum Rarer Pendants 207

INTRODUCTION

This paper is the third in a series aimed at placing on record details of interesting sections of the Maori ethnographic collection in the Australian Museum, Sydney. (The other papers are Orchiston 1970, 1971.) It deals with 58 straight greenstone pendants of *kuru mahora* and *kuru papa* forms, and 35 other pendants of *kuru kapeu* (*tautau*), *hei matau*, *koropepe*, *pekapeka*, *poria*, *rei puta*, and anomalous forms, and of an unnamed variety here termed "triangular pendant". Most of these forms are amongst those named and described by Best (1924: 537–542; 1952: 227–232.)

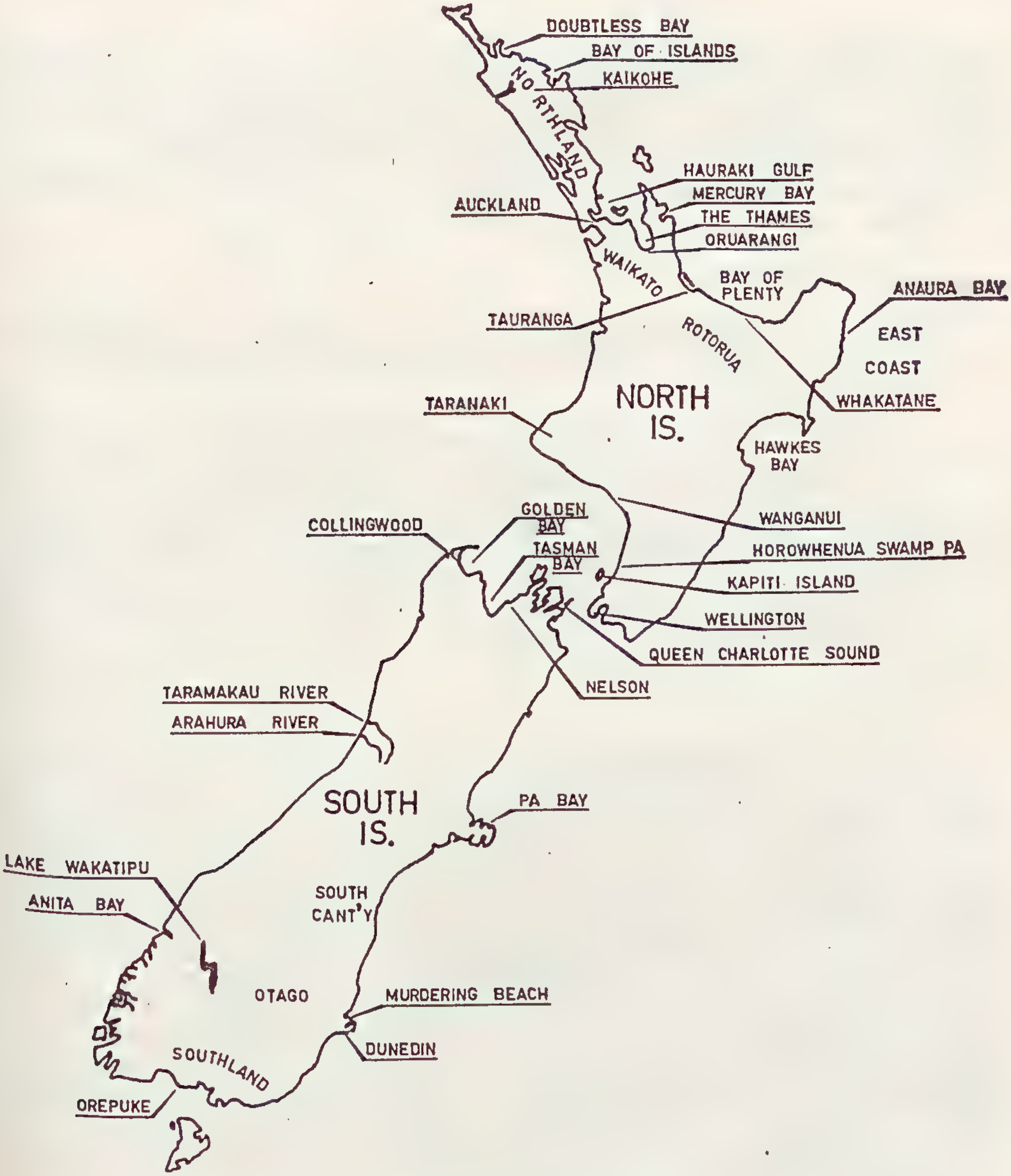


Fig. 1: Localities mentioned in the text

Best also discusses the ear pendant made from the tooth of the Mako shark, sometimes rendered in greenstone, no examples of which, however, are to be found in the Australian Museum collections, and the *tiki* and perforated chisel pendants, which are represented there but will be the subject of later studies. To this list of greenstone forms Golson (1959: 52–53) would add the *marakihau* (see Archey 1927: 72), but since this form is represented by only a very few specimens (Skinner 1933: 8), this seems a rash move. Archey (1933: 212; 1936: 51–52) and Skinner (1933: 7) claim that it is genetically related to the *pekapeka.* There are no examples in the Australian Museum.

Each of the 93 pendants investigated in this paper is described individually (either metrically or diagramatically), and where possible given a site, locality, or chronological attribution. In the case of the straight *kuru* (i.e., *kuru mahora* and *kuru papa*, combined) their abundance allows a quantitative analysis of various metrical and formal attributes. This is first preceded by an examination of the spatial-chronological distribution of the straight *kuru* population, and the characteristics of a random sample.

Most of the pendants considered in this paper, like many of the other Maori artifacts in the Australian Museum, are derived from two major sources:

(1) James Dall, formerly of Collingwood, who between the years 1886 and 1892 sold a total of 279 artifacts to the Museum. Many of these come from the Nelson Province and are localized.

(2) Sir William Dixson, who donated some 221 New Zealand artifacts to the Museum between the years 1912 and 1951. Dixson accumulated this magnificent collection, through various local and overseas sources, during the last decade of the nineteenth century and the first half of the present.

Both collections contain pendants that were manufactured with European implements ("E" specimens). Some of these were produced by the Maoris as genuine artifacts, using these new techniques of manufacture. Such pendants, although products of technological adaptation, cannot be distinguished from others that are fakes, made by Europeans. In this study all pendants produced with European implements are considered collectively and distinguished from those with a genuine appearance. These latter "M" pendants are characterized by an absence of grinding wheel striations, and an asymmetrical suspension perforation with a broad irregular arris (figure 2). Where there is some, yet not conclusive, evidence that European tools were employed pendants have been classed as "?E". This categorization system is not entirely satisfactory in that some pendants listed as "M" must in fact belong to the "E" category (as in the case of many of the "Rarer Pendants" discussed later in this paper) although they possess no obvious evidence of such a manufacture. Moreover, Skinner (1969) has outlined how realistic-looking faked pendants, through handling by a generation or two of Maoris (thus imparting a characteristic silkiness or soapiness to the surface), can actually be transformed from fakes into "genuine" artifacts. Fortunately such pendants are rare.

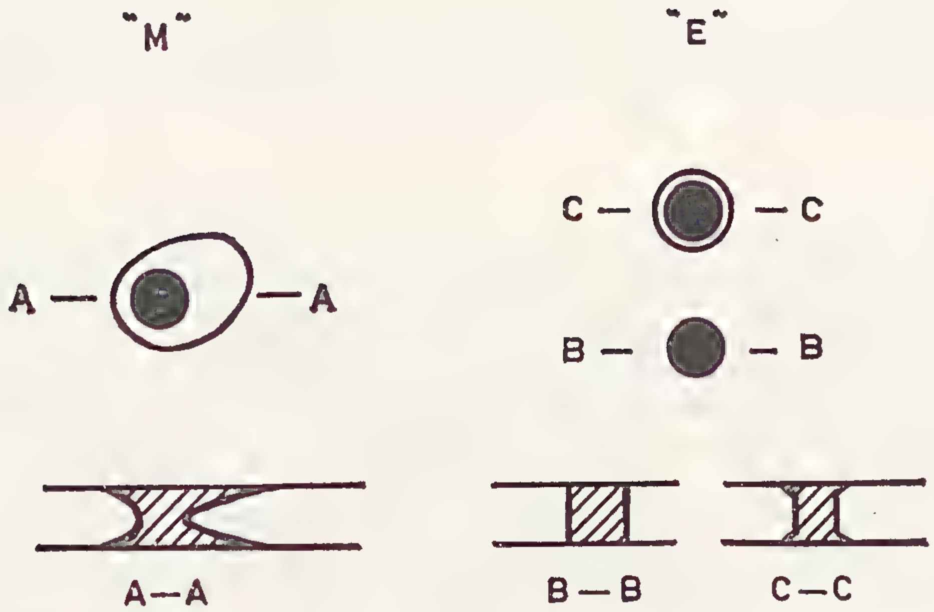


Fig. 2: Characteristics of "M" and "E" perforations

In this paper "greenstone" is held to include both semi-nephrite/nephrite (the essential constituents of which are either tremolite $H_2Ca_2Mg_5(SiO_3)_8$ or actinolite $H_2Ca_2 (MgFe)_5 (SiO_3)_8$) and bowenite (composed mainly of a mineral of the serpentine group, $H_2Mg_3(SiO_3)_4$). In hardness bowenite is little inferior to nephrite and semi-nephrite (Turner 1935: 203). Nephrite, because of its highly felted crystalline microstructure, is much tougher and less fissile than semi-nephrite, while bowenite lies at the opposite end of the fissility-toughness continuum (Turner 1935: 204). In the hand specimen it is sometimes impossible to distinguish semi-nephrite from bowenite.

Little is known of "traditional" Maori techniques employed in greenstone working, although there are Heaphy's observations made at the Taramakau River in 1846:

> "We found here six men and about fifteen women, with a large proportion of children. The inmates of each house were busily engaged in making *meri pounamu* and ear pendants of that material for 'trade' or presents to the northward. They saw the slab with a piece of mica slate, wet, and afterwards polish it with a fine sandy limestone which they obtain in the vicinity. The hole is drilled with a stick pointed with a piece of Pahutani flint. The process does not appear as tedious as has been supposed; a month sufficing, apparently, for the completion of a *meri* out of the rough but approximately shapen slab." (Heaphy 1846: 237. Cf. Best 1912: 49–86; Chapman 1891: 497–501, 511–513, 515–516, 519, 525–526; Heaphy 1862).

Nephrite and semi-nephrite were obtained by the Maoris from both the Taramakau-Arahura and Lake Wakatipu areas, while bowenite, the *tangiwai* of the Maori (see Coutts 1971), came from Anita Bay, Milford Sound (see figure 1 and Beck 1970).

Throughout this paper a tripartite chronological system is employed. The term "prehistoric" relates strictly to the period prior to 1769 (at which date Cook rediscovered New Zealand) but, since Maori material culture did not undergo immediate Pakeha-induced modification, documentation from the 1770's (Cook, Surville, and Du Fresne voyages) is often used in prehistoric reconstructions. In this way the end-point of the prehistoric period can be accurately delineated. The "protohistoric period" which followed is characterized by sporadic documentation in some areas and virtually none in others, and saw the breakdown of Maori society and culture due to the disruptive influences of European settlement. By 1850, with the commencement of the "historic period", there was European settlement throughout much of New Zealand, and in most areas traditional Maori society and culture had vanished. This period brought with it a wealth of historical documentation.

STRAIGHT *KURU*

More than 60 per cent of Australian Museum greenstone pendants are straight *kuru:* thin, highly polished, near parallel-sided, cigar-shaped objects, between 40 and 170 mm in length, and with circular to oval or double convex cross-sections. Best (1952: 227) identifies two straight *kuru* types (*kuru mahora* and *kuru papa* respectively described as "straight" and "flattened") but does not elaborate. Perhaps L'Horme's (1769–70: 323) observations on the Doubtless Bay Maoris in 1769 are relevant:

> ". . . all have holes in the lobe of the ears—men and women—and from these holes hang different ornaments. The most common is a kind of stone of a green colour . . . These stones are sometimes shaped like a cylinder pointed at the bottom, sometimes they are flat like playing counters."

A cursory examination failed to reveal these two forms amongst Australian Museum pendants, and, instead, it was found to be easier and more expedient to subtype straight *kuru* according to cross-sectional morphology. The two subtypes adopted for this study are termed A and B, the latter with B1 and B2 components. A, B1, and B2 refer to rectangular, oval, and double convex cross-sections respectively, and theoretically encompass, in each case, the full range of width/thickness ratios from 1·0 to infinity (see figure 3).

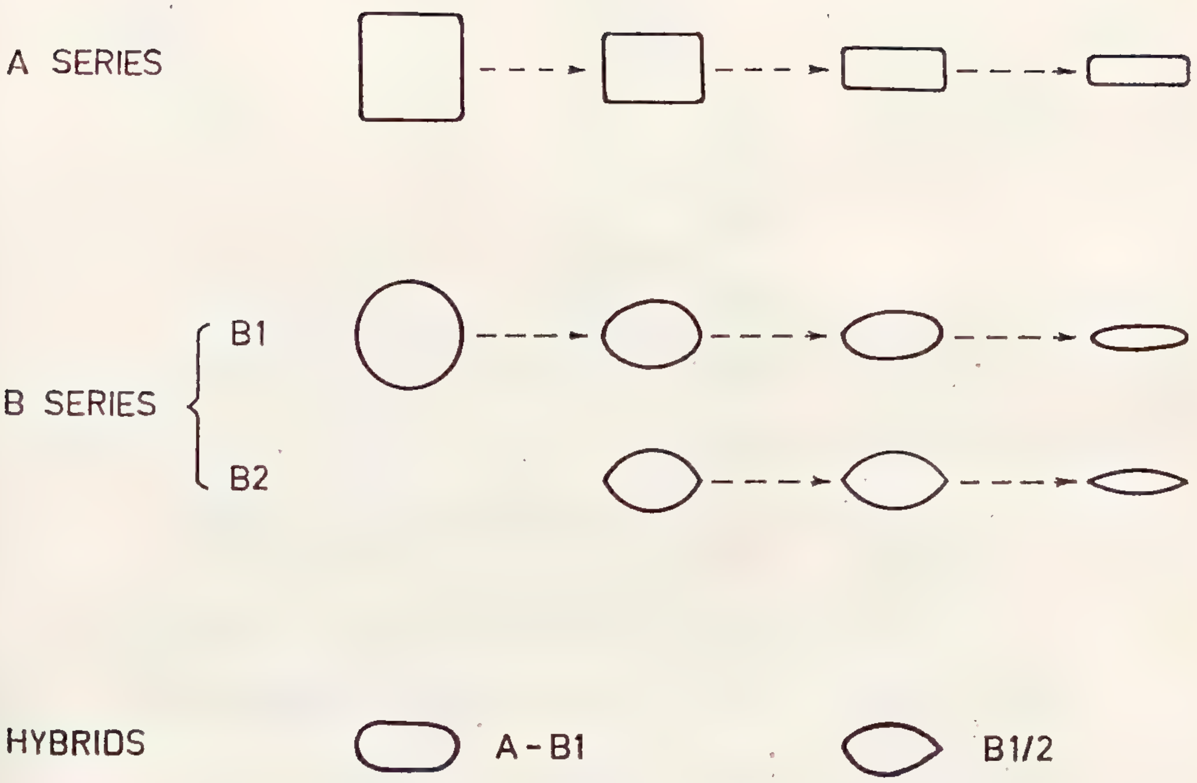


Fig. 3: Cross-sectional continua categories for straight *Kuru*

(1) Descriptions of the Pendants

Table 1 lists details of all straight *kuru* in the Australian Museum. Entries include measurements of total pendant length; distance from the proximal end of the pendant to the centre of the suspension perforation; internal diameter of the suspension perforation; pendant width, measured perpendicular to the axis of the suspension perforation, at both one-third (0·33) and two-thirds (0·66) of the distance from proximal to distal ends, at the location of the greatest width, and at the perforation; and some corresponding thickness measurements. Entries under "Distal End" relate to shape: R = rectangular, C = circular, E = elliptical, P = parabolic, and H = hyperbolic. As in later tables methods of acquisition include presentation (D), exchange (E), and purchase (P). All measurements given in the tables appearing in this paper are in millimetres to one decimal place.

Pendants E 54454 to E 54518 inclusive are from the Dixson Collection, whilst H 332 and H 333 were amongst "Cook Relics" purchased from Calvert, a London collector, and were reputedly derived from the Museum of Sir Joseph Banks. Elsewhere the author has shown (Orchiston 1970) that Calvert's claims should sometimes be regarded with suspicion.

TABLE 1. AUSTRALIAN MUSEUM STRAIGHT *KURU*

Register number	Cross section	Length (l)		Perf. dia.	Width (w)				Thickness (t)			w/t			Distal end	Manufacture	Acquisition		Remarks
		Total	To perf.		At perf.	0·33	0·66	Max.	0·33	0·66	At $w_{(max)}$	0·33	0·66	At $w_{(max)}$			Method	Date	
E 487	B1	69·2	6·4	2·6	8·5	9·3	9·3	9·4	7·3	7·8	8·1	1·3	1·2	1·2	P	E	P	1887	Dall Collection.
E 488	B1	76·5	7·3	2·2	10·3	13·5	14·1	14·1	5·7	5·9	6·0	2·4	2·4	2·4	E	?E	P	1887	Dall Collection.
E 1896	A-B1	48·5	9·0	1·7	16·8	17·4	17·3	17·4	6·4	6·4	6·4	2·7	2·7	2·7	P	M	P	1888	Dall Collection. Riwaka.
E 1897	B1	59·8	5·9	2·9	8·3	10·3	11·3	11·4	7·5	8·0	7·8	1·4	1·4	1·5	R	E	P	1888	Dall Collection. "Nelson."
E 2374	B1/2	87·3	6·1	3·5	9·6	10·4	10·3	10·4	5·8	5·8	5·8	1·8	1·8	1·8	H	M	P	1889	Great Barrier Island.
E 2375	B1	⩾78·4	3·2	2·3	7·7	9·2	9·7	10·0	8·6	8·7	9·0	1·1	1·1	1·1	H	M	P	1889	Great Barrier Island. Broken at former perforation.
E 2400	B1	121·0	8·6	2·6	13·4	15·8	17·5	17·5	14·3	15·9	16·4	1·1	1·1	1·1	P	M	P	1889	
E 2669	B1	62·3	8·4	3·0	12·9	15·4	16·9	17·1	12·7	13·5	13·6	1·2	1·3	1·3	P	M	P	1890	Dall Collection. From a Maori killed at Gate Pa (hence predates 1864).
E 2670	B1	51·8	6·5	4·6	14·1	16·5	16·6	16·9	3·9	4·2	4·4	4·2	4·0	3·8	C	M	P	1890	Dall Collection. Pakawau.
E 3553	B1	157·5	4·0	3·2	10·0	14·2	14·3	14·9	12·9	13·0	13·6	1·1	1·1	1·1	E	E	P	1892	
E 9241	B1	115·0	5·6	2·6	7·8	10·0	10·6	10·8	9·2	9·7	9·6	1·1	1·1	1·1	P	M	P	1900	
E 9242	B1	150·0	5·0	2·9	10·2	11·9	11·1	12·1	8·3	8·2	8·9	1·4	1·4	1·4	P	M	P	1900	
E 35342	B1	68·9	7·4	3·4	15·7	19·8	22·3	22·3	18·0	19·0	19·0	1·1	1·2	1·2	C	?E	P	1932	
E 54454	B2	86·3	6·6	3·0	11·6	12·8	13·9	14·0	2·5	2·6	2·8	5·1	5·4	5·0	E	E	D	1951	
E 54472	B1	168·0	13·7	5·9	27·3	32·8	35·4	36·2	12·9	12·9	12·3	2·5	2·7	2·9	C	M	D	1951	
E 54473	B1	149·5	8·6	3·6	16·8	19·0	20·5	21·5	6·9	7·2	7·9	2·8	2·8	2·7	C	?E	D	1951	
E 54474	B1	139·0	10·0	3·5	13·0	16·0	17·5	18·1	9·4	10·8	10·9	1·7	1·6	1·7	E	E	D	1951	
E 54475	B1	115·5	6·1	4·2	10·5	15·7	16·0	16·0	8·2	9·5	9·7	1·9	1·7	1·7	P	E	D	1951	
E 54476	B1	124·0	11·4	5·6	17·1	20·1	21·3	21·5	6·0	6·1	6·4	3·4	3·5	3·4	E	M	D	1951	
E 54477	B1	122·0	11·6	2·6	11·0	15·1	17·7	17·8	6·6	6·9	6·9	2·3	2·6	2·6	P	M	D	1951	
E 54478	B1	114·0	7·8	4·0	16·4	19·8	18·7	20·0	10·0	9·8	9·8	2·0	1·9	2·0	P	M	D	1951	
E 54479	B1	105·1	8·7	5·2	14·0	19·5	19·6	20·2	8·7	8·8	9·0	2·2	2·2	2·2	P	M	D	1951	
E 54480	B1	86·9	6·8	2·9	13·2	17·1	19·2	20·0	6·6	6·9	6·7	2·6	2·8	3·0	C	M	D	1951	
E 54481	B1	111·6	10·1	3·7	10·8	13·8	14·3	14·4	6·7	6·5	6·8	2·1	2·2	2·1	P	M	D	1951	
E 54482	B2	103·0	7·0	3·1	13·9	21·0	20·9	21·0	8·3	8·7	8·7	2·5	2·4	2·4	E	M	D	1951	
E 54483	B1	86·4	6·1	4·0	13·4	20·4	21·5	21·5	6·4	6·7	6·7	3·2	3·2	3·2	P	M	D	1951	
E 54484	B2	87·2	10·9	2·6	12·9	15·8	15·7	15·8	8·9	8·1	8·7	1·8	1·9	1·8	H	M	D	1951	
E 54485	B1	81·6	8·7	3·2	15·6	18·9	19·1	19·1	10·5	12·0	12·0	1·8	1·6	1·6	C	M	D	1951	

TABLE 1. AUSTRALIAN MUSEUM STRAIGHT *KURU*—continued

Register number	Cross section	Length (l)		Perf. dia.	Width (w)				Thickness (t)			w/t			Distal end	Manu-facture	Acquisition		Remarks
		Total	To perf.		At perf.	0·33	0·66	Max.	0·33	0·66	At $w_{(max)}$	0·33	0·66	At $w_{(max)}$			Method	Date	
E 54486	B1	94·5	7·8	3·1	13·5	14·8	14·6	14·9	9·7	9·5	9·4	1·5	1·5	1·6	H	M	D	1951	
E 54487	B1	93·6	10·0	2·9	11·0	13·7	15·3	15·4	6·3	6·7	6·7	2·2	2·3	2·3	P	M	D	1951	
E 54488	B1	72·6	6·0	3·2	12·5	14·9	16·8	16·9	8·1	8·3	8·6	1·8	2·0	2·0	E	M	D	1951	
E 54489	B2	95·5	6·8	3·0	13·9	17·8	18·8	18·8	5·9	5·2	5·2	3·0	3·6	3·6	E	E	D	1951	
E 54490	B1	79·6	6·9	3·1	12·1	13·5	12·4	13·6	8·1	7·4	8·2	1·7	1·7	1·7	E	M	D	1951	
E 54491	B1	78·2	7·1	2·9	13·7	17·1	16·4	17·1	7·2	6·7	7·2	2·4	2·4	2·4	P	M	D	1951	
E 54492	B2	81·1	5·8	2·6	11·4	14·5	15·6	15·7	6·0	6·4	6·1	2·4	2·4	2·6	P	M	D	1951	
E 54493	B2	61·8	4·7	2·2	19·8	21·6	22·4	22·4	7·1	7·2	6·8	3·0	3·1	3·3	C	M	D	1951	
E 54494	B1	78·4	7·8	3·0	10·9	14·6	15·3	15·5	8·4	8·9	8·9	1·7	1·7	1·7	E	M	D	1951	
E 54495	B1	78·8	6·5	2·4	8·8	12·6	13·7	13·9	5·1	5·4	5·5	2·5	2·5	2·5	E	M	D	1951	
E 54496	B2	66·5	7·0	3·0	16·2	18·4	19·6	19·6	6·6	7·4	7·4	2·8	2·7	2·7	C	M	D	1951	
E 54498	B1	68·2	11·3	3·9	14·0	14·8	15·0	15·0	7·4	7·8	7·8	2·0	1·9	1·9	E	M	D	1951	
E 54499	A-B1	54·3	6·7	2·0	10·5	12·4	13·4	13·4	3·2	3·5	3·5	3·9	3·8	3·8	E	M	D	1951	
E 54500	B1	43·7	5·4	3·0	13·0	16·9	17·0	17·7	6·4	6·4	6·4	2·6	2·7	2·8	P	M	D	1951	
E 54501	B1	54·1	7·5	3·5	11·8	13·9	14·8	14·9	5·7	6·1	6·2	2·4	2·4	2·4	E	?E	D	1951	
E 54505	B1	78·8	6·6	3·2	9·4	11·1	11·1	11·5	5·0	5·0	4·8	2·2	2·2	2·4	H	E	D	1951	
E 54506	B1	76·2	7·0	2·1	9·8	11·0	12·7	12·7	6·6	6·7	6·7	1·7	1·9	1·9	P	M	D	1951	
E 54507	B1	89·1	4·0	2·8	8·1	10·0	10·3	10·3	6·4	6·0	6·0	1·6	1·7	1·7	E	E	D	1951	
E 54508	B1	78·4	7·2	1·7	8·6	10·6	11·9	12·3	6·7	7·7	7·5	1·6	1·5	1·6	C	?E	D	1951	
E 54509	B1	⩾117·0	..	~2·2	7·9	8·9	8·0	8·9	5·8	4·9	5·8	1·5	1·6	1·5	P	M	D	1951	Broken at the perforation.
E 54510	B1	120·5	6·2	3·6	11·0	15·2	15·8	15·8	11·4	13·0	13·0	1·3	1·2	1·2	E	M	D	1951	
E 54512	B1	72·2	7·5	3·9	10·1	13·2	13·5	14·0	10·9	11·6	12·0	1·2	1·2	1·2	P	M	D	1951	
E 54513	B1	63·6	4·1	2·6	10·6	13·2	14·0	14·4	10·2	11·7	11·8	1·3	1·2	1·2	P	M	D	1951	
E 54514	B1	57·4	5·9	2·2	7·4	8·6	9·6	9·9	7·2	8·7	8·6	1·2	1·1	1·2	C	M	D	1951	
E 54515	B1	53·5	4·9	3·1	7·3	12·0	12·4	12·8	11·3	11·3	11·9	1·1	1·1	1·1	H	M	D	1951	
E 54516	B1	82·2	6·9	2·7	10·6	11·3	10·8	11·4	11·1	10·8	11·3	1·0	1·0	1·0	E	M	D	1951	
E 54518	B2	81·0	6·8	2·8	15·2	18·1	19·3	19·4	4·7	4·9	4·8	3·9	3·9	4·0	E	M	D	1951	
H 332	B1	61·0	3·5	2·0	6·5	7·5	7·8	8·3	6·4	6·4	6·0	1·2	1·2	1·4	E	M	D	1895	
H 333	B1	90·2	6·2	3·4	9·4	12·7	12·6	13·0	11·2	10·9	11·3	1·1	1·2	1·2	P	M	D	1895	
None	B1/2	144·0	5·6	2·2	15·1	21·8	19·7	22·8	6·7	5·6	6·8	3·3	3·5	3·4	P	M	?	?	

(2) Site, Locality, and Chronological Attributions

Localized straight *kuru* are featured in figure 4. E 1896 is from Riwaka, which, on artifactual (Nelson, Australian, and other Museums; Duff 1949: 128), traditional (see Peart 1937: 52, 54, 58–63, 67–68), and protohistoric evidence (Field

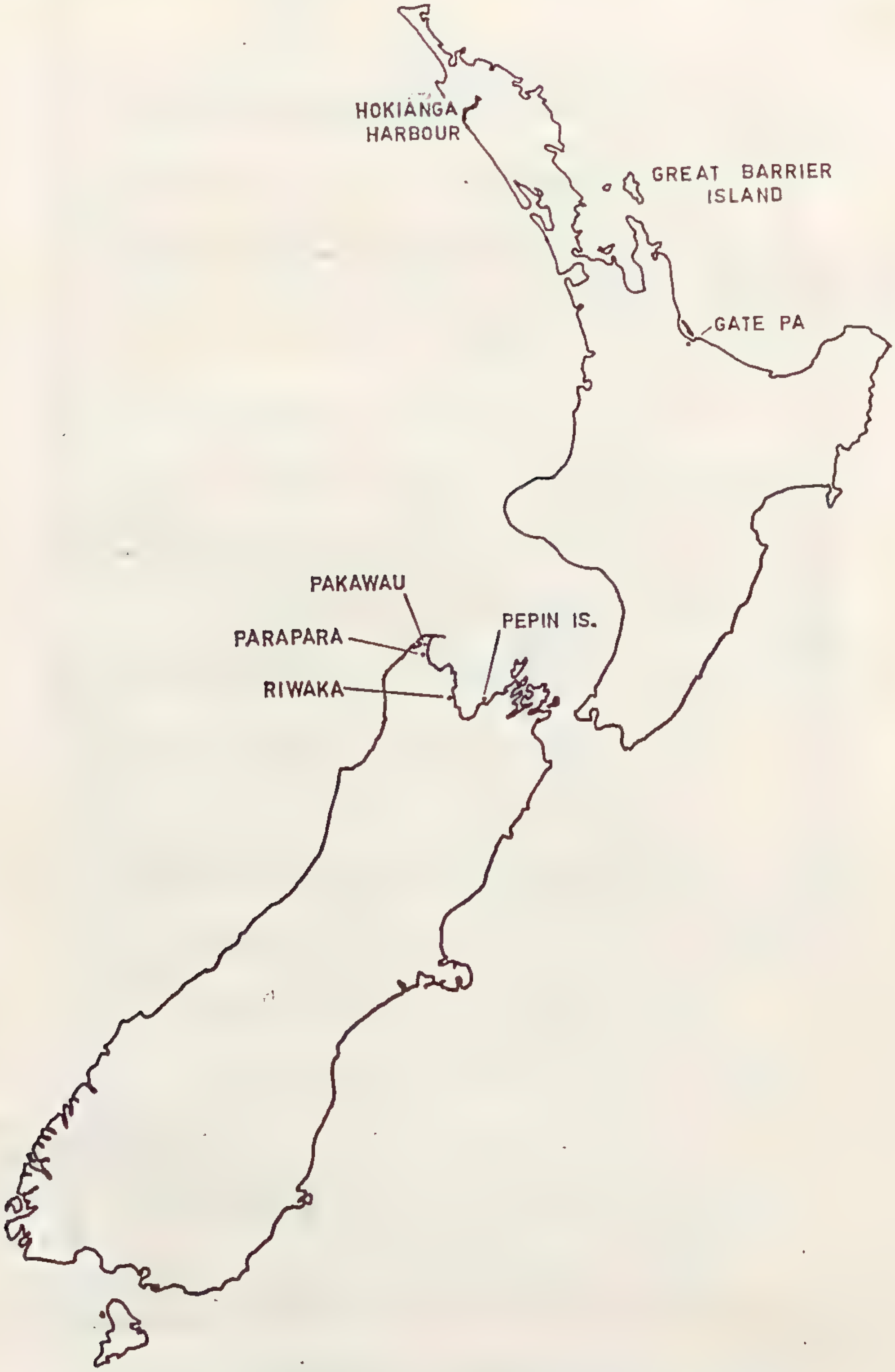


Fig. 4: Distribution of localized Australian Museum pendants

1942: 89–90, 115–117, 138; Peart 1937: 102–103; and early maps in the Lands and Survey Office, Nelson) was the site of both prehistoric and protohistoric Classic Maori settlements. Pendants E 2374 and E 2375 are from Great Barrier Island where Classic Maori sites are apparently abundant (Spring-Rice 1962, 1963). E 2669 was obtained from a Maori killed at Gate Pa, and so pre-dates 1864. Pakawau, the locality from which E 2670 came, was the site of a protohistoric settlement (Heaphy 1846: 205; Tuckett 1842: 64–65). Field survey work by the author in December 1969 revealed that Classic Maori sites and artifacts were abundant around the Inlet and along the narrow coastal strips immediately to the north and south.

Although genuine "Cook Relics" cannot often be localized, some conclusions are possible. It has been shown (Orchiston 1972a) that during Cook's first voyage there were no localities where any quantity of greenstone pendants could possibly have been traded, although the odd specimen may have been picked up at the Bay of Islands, Mercury Bay, or Anaura Bay. In all likelihood H 322 and H 333, if genuine Cook relics, came from Queen Charlotte Sound during the second or third voyages, where much trafficking in greenstone occurred (Orchiston 1972b).

(3) The Problems of Sampling

The population of straight *kuru* to which the Australian Museum sample belongs possesses both spatial and chronological attributes, and includes all pendants manufactured with native implements in all geographical areas of New Zealand throughout the entire prehistoric, protohistoric, and historic periods.

Published accounts of indisputably prehistoric straight *kuru* (from either North or South Island) are exceedingly rare (Meeson 1889; 69, f70; Skinner 1936: figure 6) and in each case the pendant concerned differs markedly from table 1 examples. Nor is there any indication that straight *kuru* were anywhere abundant,

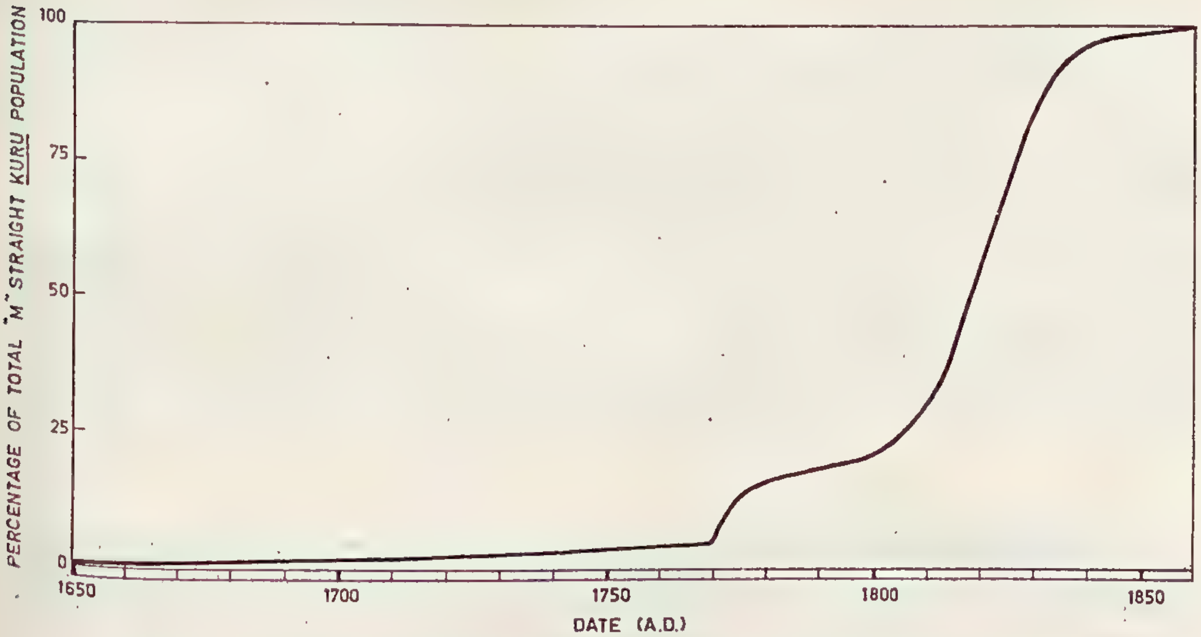


Fig. 5: Cumulative frequency curve for the "M" straight *Kuru* population

except perhaps in Northland, in 1769–1770. However, these pendants were being manufactured for trade with Europeans as early as 1773 (Orchiston 1972b), and during the second and third decades of the nineteenth century the increased tempo of Maori-Pakeha trade relations led to an efflorescence in greenstone ornament manufacture, which continued through into the 1840's (as witnessed at the Taramakau River by Heaphy). This rapid, yet irregular, numerical increase in the straight *kuru* population is illustrated graphically in figure 5, where it can be seen that the great majority of "M" pendants currently in museums and private collections were produced in protohistoric times, largely in response to European demand. Very few "M" *kuru* were manufactured during historic times, although "E" specimens became abundant from about 1865. Dr Skinner (1969) attributes the latter to:

(1) the availability of a plentiful supply of fine nephrite, as a result of gold-sluicing in the Taramakau and Arahura Rivers;

(2) the ease with which pendants could be manufactured with metal discs and carborundum;

(3) the impact on European thought on traditional Maori beliefs relating to the sanctity of pendants.

To these may be added:

(4) the insatiable demand from both private collectors and the world's museums.

"It is clear," states Skinner, "that the demand for faked amulets in nephrite and in bone was met principally by the Auckland experts, the most skilled of whom was Trevor Lloyd . . ." Conly (1948) gives an account of early Dunedin fakers.

Precise determination of the spatial-chronological distribution of "M" straight *kuru* is an almost impossible task. In all likelihood such pendants largely mirrored the distribution of human populations engaged in trading activities with Europeans. That is, prior to 1820 they were largely concentrated in Northland, with "minor pockets" at the Thames, Tauranga, Whakatane, and the East Coast area (unless *kuru kapeu* dominated here). During the 1820's there was some blossoming of these minor pockets, but the most significant feature of this interval was the emergence of the Kapiti Island trading station, which attained prominence during the 1830's as the political dominance of the Bay of Islands region waned. The 1830's also witnessed the appearance of a multitude of new minor pockets all around the coast—but particularly the East Coast of the North Island from Hauraki Gulf south, but with isolated West Coast locations (e.g., Taranaki Coast, Wanganui)—and in the interior (principally the Waikato and Rotorua regions). During the 1840's the Wellington, Golden Bay, and Tasman Bay areas were added.

During protohistoric times non-straight *kuru*, or straight *kuru* differing markedly from those of table 1, were commonly produced in east-coast South Island (Skinner 1932: 302–309; Skinner 1933: 1–10, 310–320; Skinner 1959; Teviotdale 1939: 111–113; Thacker 1961: 10–11; and Trotter 1967: 240–241).

Although most museum "M" straight *kuru* were manufactured for trade a number of cultural and non-cultural variables entered into pendant manufacture and combined to determine the form of the finished products. Rouse (1939: 18–19) has enumerated these:

(1) Chance.
(2) Individual quirks of the artisan.
(3) Physical capacities of the artisan.
(4) Potentialities of the environment.
(5) Elements of Culture.
  (a) Types—
    (i) styles.
  (b) Modes—
    (i) techniques.
    (ii) designs.
    (iii) other specifications.

The influence of chance is apparent in the case of pendants E 2375 and E 54509, while environmental potentialities played a role in that the different fissility-toughness characteristics of bowenite, nephrite, and semi-nephrite must have related to ease of working. But factors 2, 3, and 5 were undoubtedly the most crucial ones, with their interaction leading to differences in metrical attributes of straight *kuru* from one trade location within New Zealand to another during the protohistoric period. And, in the course of time, as different artisans emerged and others died; as human population numbers and distributions altered (through warfare, tribal and intra-tribal amalgamation or segmentation, migration, varying natural birth/death rates, natural catastrophes, etc.), and different geographical areas waxed and waned in trading prominence; as styles altered and manufacturing techniques possibly changed, the metrical attributes of this increasing population of straight *kuru* must statistically have undergone diachronic change.

Thus, the following criteria must ideally be met if a sample of such pendants is to be considered truly random:

(1) All localities which at any time (prehistoric, protohistoric, or historic) possessed "M" straight *kuru* must be represented; and
(2) The number of pendants representing each such location must—
  (a) be proportional to the total numerical contribution made by that location to the total population; and
  (b) in chronological distribution reflect diachronic changes in numerical abundance.

Rarely are data so stringently defined as to satisfy these criteria. However, a random sample may be approximated on the basis of figure 5, in that about 70 per cent of the "M" straight *kuru* population were manufactured during the interval 1810–1840, and that these pendants were derived almost exclusively from Northland, Kapiti Island, the Thames, Bay of Plenty, and the East Coast regions.

Most of the Australian Museum sample is derived from the one collection built up during historic times, hence the majority of its pendants can be associated with protohistoric manufacture. But since there is no evidence of geographical distribution the randomness of this sample must be questioned.

TABLE 2. AUCKLAND MUSEUM STRAIGHT *KURU*

Register number	Cross section	Length (l)		Perf. dia.	Width (w)				Thickness (t)			w/t			Distal end	Remarks
		Total	To perf.		At perf.	0·33	0·66	Max.	0·33	0·66	At $w_{(max)}$	0·33	0·66	At $w_{(max)}$		
339	A-B1	125·7	9·2	3·0	11·9	12·8	12·4	12·9	8·4	8·4	8·3	1·5	1·5	1·6	E	Obtained 1893 from Tuitai, oldest Maori at Omawharo Native Settlement, Kaipara.
343	B1	96·0	10·2	4·9	14·4	17·1	17·9	18·1	16·4	17·5	17·5	1·0	1·0	1·0	C	Chatham Islands.
351	B1/2	63·9	7·7	3·8	13·5	17·4	21·1	21·3	5·7	5·2	5·0	3·1	4·1	4·3	C	
352	B1	59·6	7·0	3·4	12·2	13·5	13·3	13·5	9·0	10·4	9·0	1·5	1·3	1·5	C	
584	B1	62·8	7·3	4·4	11·4	13·1	13·0	13·3	9·2	9·5	9·5	1·4	1·4	1·4	C	East Cape.
639	B1	75·2	3·4	3·3	6·2	7·6	7·8	7·8	6·0	6·4	6·4	1·3	1·2	1·2	E	Burial Cave near Ohaewai.
3049	B1	43·3	6·7	3·2	10·0	11·3	11·6	11·9	8·7	8·8	9·0	1·3	1·3	1·3	P	Probably near Kaikohe.
3051	B1/2	68·2	7·4	4·5	11·9	13·4	15·3	15·9	5·8	6·9	7·3	2·3	2·2	2·2	C	Probably near Kaikohe.
3248	B1	96·3	8·8	4·6	10·8	12·4	12·0	12·4	6·5	7·5	6·5	1·9	1·6	1·9	E	
3350	B2	67·3	8·8	4·6	10·6	12·1	13·7	14·1	5·5	5·8	5·8	2·2	2·4	2·4	E	
3920.1	B1	59·7	3·7	3·7	9·8	11·4	10·6	11·4	4·5	5·1	4·5	2·5	2·1	2·5	E	Kawakawa.
3920.2	B1	72·9	4·9	3·0	9·2	9·9	9·7	9·9	5·8	6·1	5·8	1·7	1·6	1·7	E	Kawakawa.
3920.4	B1	74·1	8·3	4·2	11·1	11·2	10·4	11·2	11·0	10·2	11·0	1·0	1·0	1·0	H	
4328	B1	53·2	3·3	1·9	5·2	6·5	6·1	6·5	3·7	3·8	3·7	1·8	1·6	1·8	C	
5043	B1	121·8	8·3	5·0	12·4	15·0	16·1	16·2	7·0	7·3	7·3	2·1	2·2	2·2	P	
5535	B1	109·8	7·7	2·8	8·6	10·7	10·3	10·8	5·3	5·3	5·3	2·0	1·9	2·0	P	On the Summit of One Tree Hill.
5575	B1	93·9	10·2	4·6	11·3	12·4	11·2	12·4	8·3	8·2	8·3	1·5	1·4	1·5	H	
5623	B1	107·4	7·0	2·7	14·0	17·2	15·3	17·6	11·6	11·0	11·2	1·5	1·4	1·6	P	
5624	B1	86·0	5·6	3·3	10·4	9·7	8·3	10·6	5·9	5·1	6·4	1·6	1·6	1·7	E	
5626	B1	66·3	9·9	3·6	10·4	10·9	10·0	10·9	7·6	7·2	7·6	1·4	1·4	1·4	P	
5627	B1	43·6	7·0	3·4	8·5	8·6	8·0	8·9	4·2	4·8	4·9	2·0	1·7	1·8	H	
6130	B1	82·2	6·2	4·3	11·0	14·6	14·8	15·2	9·7	9·4	9·9	1·5	1·6	1·5	E	Reputedly used in *makutu*. Name: Te Parakore.
6260	B1	68·6	7·7	2·9	10·0	12·0	11·6	12·0	6·1	6·1	6·1	2·0	1·9	2·0	P	Burial ground, Mayor Island.
6410	B1	72·1	6·9	3·9	12·2	16·1	15·7	16·3	6·7	6·7	6·6	2·4	2·3	2·5	C	Found in a skull in a burial cave at Ohaewai
6684	B1	66·3	3·6	2·4	7·7	8·6	8·2	8·8	8·2	7·7	8·3	1·0	1·1	1·1	P	North Cape district.
7617	B1	70·9	7·4	3·7	10·3	15·0	14·1	15·1	8·6	8·5	8·6	1·7	1·6	1·8	P	Murdering Beach.
8291	B1	90·6	10·9	3·7	12·6	16·3	19·7	19·7	9·6	10·9	10·9	1·7	1·6	1·6	E	Urewera.
8296	B1	59·2	9·0	4·8	15·1	16·3	14·4	16·3	9·6	9·3	9·6	1·7	1·6	1·7	H	Urewera.
13664	B1	95·2	8·7	4·0	18·9	19·7	20·0	20·0	5·6	6·0	6·0	3·3	3·3	3·3	C	Rotorua.
13959	B1	74·5	8·2	4·4	11·8	12·6	12·1	12·6	6·6	6·4	6·6	1·9	1·9	1·9	P	Bay of Plenty.
13963	B1	64·5	5·2	4·0	13·2	15·4	16·1	16·1	6·8	6·4	6·4	2·3	2·5	2·5	E	Kaipara.
16133	B1	103·1	3·7	3·2	5·9	8·6	7·5	8·6	5·8	5·2	5·8	1·5	1·4	1·5	H	Totara North.
16138.1	B1	71·7	4·4	2·5	6·6	8·3	7·9	8·4	3·9	3·7	4·0	2·1	2·1	2·1	H	Kaipara.
16175	B1	111·6	4·0	1·8	6·2	7·7	7·8	8·2	7·4	7·4	7·7	1·0	1·1	1·1	E	North Cape.

TABLE 2. AUCKLAND MUSEUM STRAIGHT *KURU*—continued

Register number	Cross section	Length (l)		Perf. dia.	Width (w)				Thickness (t)			w/t			Distal end	Remarks
		Total	To perf.		At perf.	0·33	0·66	Max.	0·33	0·66	At $w_{(max)}$	0·33	0·66	At $w_{(max)}$		
16177	B1/2	63·5	7·1	2·9	14·0	19·5	19·7	20·4	6·4	6·5	6·6	3·0	3·0	3·1	E	North Cape.
16684	B2	128·4	10·0	6·2	15·5	19·7	16·8	19·7	5·4	4·4	5·4	3·8	3·8	3·8	E	Whakatane.
17491.2	B1	86·5	10·4	4·3	13·4	15·6	15·1	15·7	9·4	7·6	9·0	1·6	2·0	1·7	P	
19223.1	B1/2	73·8	6·1	4·4	9·5	10·4	10·3	10·4	3·9	4·2	3·9	2·7	2·5	2·7	E	Moturiki, Tauranga.
19555.3	B1	56·0	6·9	4·7	9·5	10·9	11·1	11·1	8·1	8·1	8·1	1·3	1·4	1·4	C	Oruarangi.
20080.1	B1	105·1	11·8	4·5	15·7	15·6	12·9	16·2	9·0	7·9	8·7	1·7	1·6	1·9	H	
20080.2	B1	134·8	6·5	3·8	10·9	9·9	7·9	11·2	9·3	8·3	8·5	1·1	1·0	1·3	E	
22391	B1	77·9	8·8	4·7	12·3	14·8	15·2	15·5	5·9	5·9	5·9	2·5	2·6	2·6	E	
22473.3	B1	58·0	5·3	3·9	10·6	12·9	12·8	13·0	4·1	4·3	4·4	3·1	3·0	3·0	E	Lake Okataina.
22802	B1	99·6	4·8	4·2	7·6	10·5	10·7	10·7	5·7	5·3	5·3	1·8	2·0	2·0	C	? Marlborough Sounds.
22841.2	B1	69·7	5·4	4·1	10·5	13·1	12·8	13·3	9·9	9·6	9·9	1·3	1·3	1·3	P	
22881	B1	80·8	9·2	5·2	11·4	12·1	10·1	12·1	5·9	5·3	5·9	2·0	1·9	2·0	P	
23490	B1/2	98·2	6·3	3·7	11·9	14·6	13·3	14·7	5·9	5·9	5·8	2·5	2·3	2·5	H	
29595.1	B1	63·6	5·2	4·1	9·8	11·2	11·6	11·6	6·1	6·0	6·0	1·8	1·9	1·9	P	
30747	B1	157·2	7·5	4·0	11·9	14·4	14·3	14·6	13·1	14·1	14·0	1·1	1·0	1·0	C	
30857	B1	96·3	5·5	1·9	9·3	10·3	10·3	10·3	5·2	5·1	5·2	2·0	2·0	2·0	P	
30857.3	B1	73·3	5·0	3·8	11·8	16·4	16·9	17·3	4·8	4·8	4·8	3·4	3·5	3·6	E	
31048	B1	39·5	5·8	3·3	13·1	13·1	13·1	13·2	6·8	6·8	6·8	1·9	1·9	1·9	P	
32473.4	B1	61·2	4·2	3·1	7·2	8·5	8·7	8·7	5·7	6·1	6·1	1·5	1·4	1·4	C	
32497	B1	80·6	9·5	4·2	10·4	11·9	13·4	13·7	4·7	4·5	4·4	2·5	3·0	3·1	R	
32870	B1	68·4	6·3	3·3	10·0	10·9	9·6	11·0	9·0	8·3	8·8	1·2	1·2	1·2	C	Whangarei.
33185	B1	108·1	5·4	3·6	9·6	14·2	14·2	14·9	12·4	12·5	12·8	1·1	1·1	1·2	P	
34760.2	B1	57·9	4·2	3·0	9·1	11·6	10·9	11·7	9·6	9·2	9·8	1·2	1·2	1·2	E	Putiki.
34760.3	B1	48·0	5·2	3·5	11·8	11·8	10·9	12·0	9·4	9·1	9·2	1·3	1·2	1·3	P	Waiomio Valley.
34760.5	B1	117·6	5·6	2·8	7·7	9·6	8·8	9·6	6·1	5·6	6·1	1·6	1·6	1·6	H	Waiomio Valley.
34760.8	B1	60·6	7·6	3·3	9·3	10·5	9·9	10·5	4·2	4·1	4·2	2·5	2·4	2·5	P	Waiomio Valley.
36099.3	B1	61·4	6·9	3·2	10·6	12·4	11·0	12·4	10·0	9·4	10·0	1·2	1·2	1·2	C	Waiomio Valley.
36100.2	B2	62·4	6·5	4·2	13·0	16·8	17·1	17·1	4·0	4·5	4·5	4·2	3·8	3·8	H	
36509.2	B1	144·6	13·0	4·0	16·0	15·6	15·4	16·6	5·9	5·9	5·8	2·6	2·6	2·8	E	
36734.3	B1	144·1	4·7	3·1	5·9	6·7	6·5	6·8	6·3	5·7	6·3	1·1	1·1	1·1	P	? Taranaki.
38148	B1	55·7	5·5	1·8	8·7	10·0	11·2	11·4	8·1	10·6	11·0	1·2	1·1	1·0	H	
38172	B2	132·9	8·0	4·1	21·8	23·2	24·1	24·1	6·0	5·8	5·8	3·8	4·2	4·2	C	
39018	B1	72·8	8·2	3·5	11·9	14·1	16·5	16·9	7·5	8·4	8·7	1·9	2·0	1·9	C	
39020	B1	44·4	5·7	2·8	13·3	16·4	14·4	16·5	4·1	4·0	4·1	4·0	3·6	4·0	C	
39022	B1/2	42·6	8·4	4·0	15·1	18·6	16·9	18·9	6·7	6·3	6·7	2·8	2·7	2·8	P	
39458	B1	63·5	4·4	3·1	7·4	13·2	13·6	14·3	10·5	11·7	11·8	1·3	1·2	1·2	P	

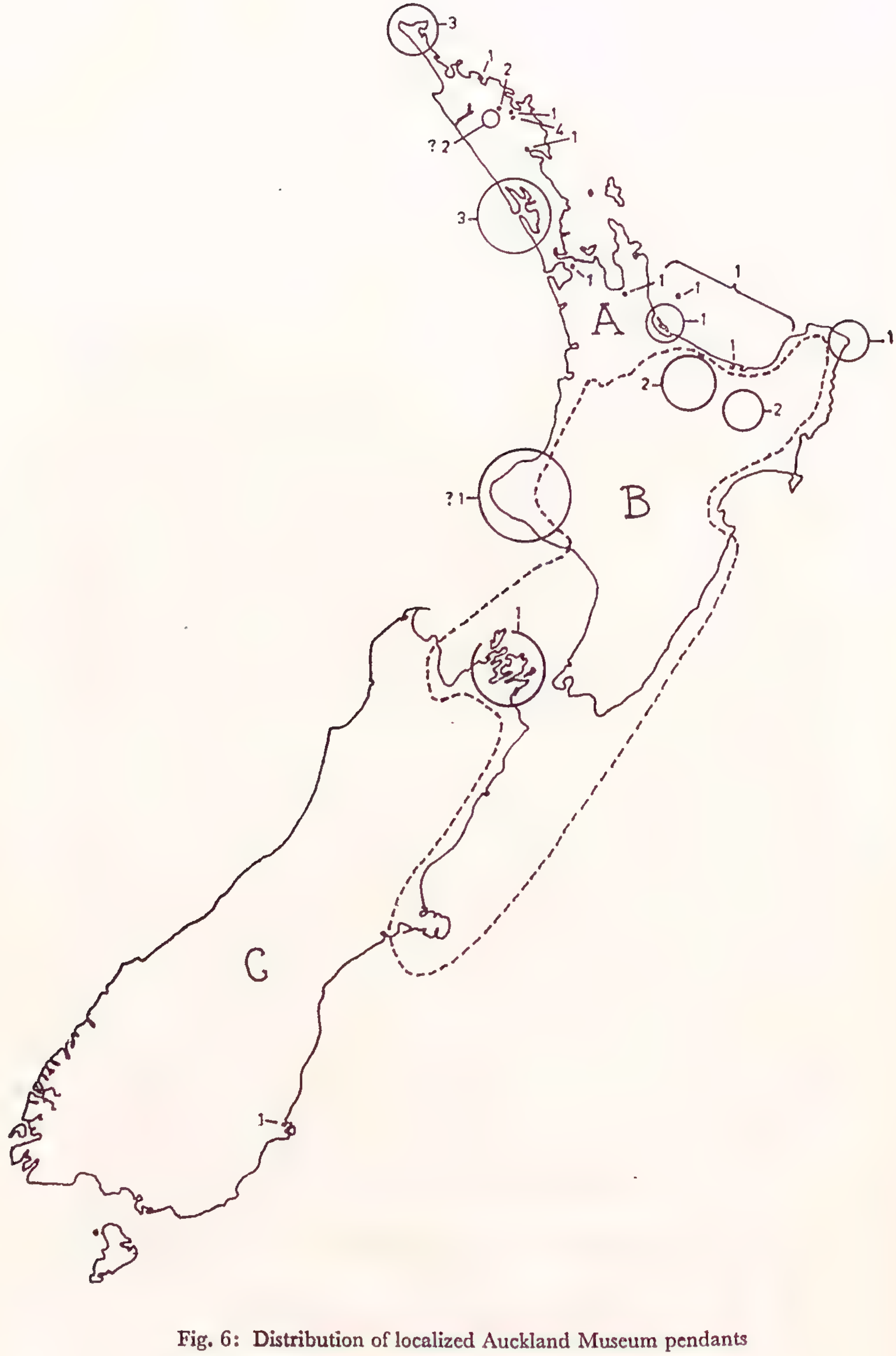


Fig. 6: Distribution of localized Auckland Museum pendants

(4) A Random Sample

In order to investigate the parameters of a random sample, and to determine the extent to which the Australian Museum pendants differ quantitatively, measurements were taken on 70 "M" straight *kuru* in the Auckland Institute and Museum (see table 2). Auckland pendants were also acquired during historic times so in most cases can be attributed a protohistoric origin. The geographical distribution of the 31 localized pendants is indicated in figure 6, showing a predominantly Northland-Bay of Plenty bias. Pendants' numbers in areas A, B, and C (25, 5, and 1, respectively) do not differ significantly at $P = 0{\cdot}05$ from Cumberland's (1950: 19) corresponding 1838 population values ($\chi^2 = 1{\cdot}23$). Thus, there are grounds for assuming that the Auckland specimens approximate a random sample, and that they are a closer approximation than the Australian Museum sample is.

Table 3 compares the numbers of pendants of different cross-sectional types from Sydney ("M" *kuru* only) and Auckland. A χ^2 analysis, incorporating Yates's Correction, revealed no significant difference between the two samples at the 0·05 level.

TABLE 3. DISTRIBUTION OF CROSS-SECTIONAL VARIETIES IN TWO SAMPLES OF "M" PENDANTS

Cross-section	Sydney	Auckland
A-B1	2	1
B1	34	59
B2	6	4
B1/2	2	6

(5) Quantitative Analyses

To date straight *kuru* have not been subjected to quantitative analysis, those few descriptions that have appeared in print all being of a subjective nature. This situation is rectified in the present paper. Following is an examination of the nature and interrelationships of various pendant parameters, both for Sydney and Auckland samples. In each case B1 specimens are differentiated from those of B2, B1/2, and A-B1 cross-sections, and in the frequency histograms these last three are plotted together for the purposes of statistical analyses. In all Australian Museum scatter diagrams "M" pendants are distinguished from "E" and "?E" specimens, while these last two are represented collectively in the corresponding histograms. Unless otherwise stated conclusions that follow relate specifically to "M" B1 pendants only.

A histogram of length for Auckland Museum straight *kuru* is given in figure 7. This sample shows a negatively-skewed Gaussian distribution with the mode at about 70 mm and a mean of 80·4 mm, both of which are consistent with Monneron's (1769–70: 283) claim that *kuru* worn by the Doubtless Bay natives of 1769 were about 3 inches (76·2 mm) in length. Since straight *kuru* worn as neck pendants appear to show a similar length range to ear counterparts on the basis of Lindauer's paintings (Graham 1965: *passim*) only in the case of the occasional long, bulky, hence heavy straight *kuru* is it functionally necessary to allocate it to the neck rather than the ear. Thus, on the basis of length alone it is impossible to distinguish neck from ear pendants. During 1769 and 1770 straight *kuru* were rarely, if ever, worn as neck ornaments (see Orchiston 1972b), and the limited evidence available suggests this practice only came into vogue in late protohistoric times, or during the historic period.

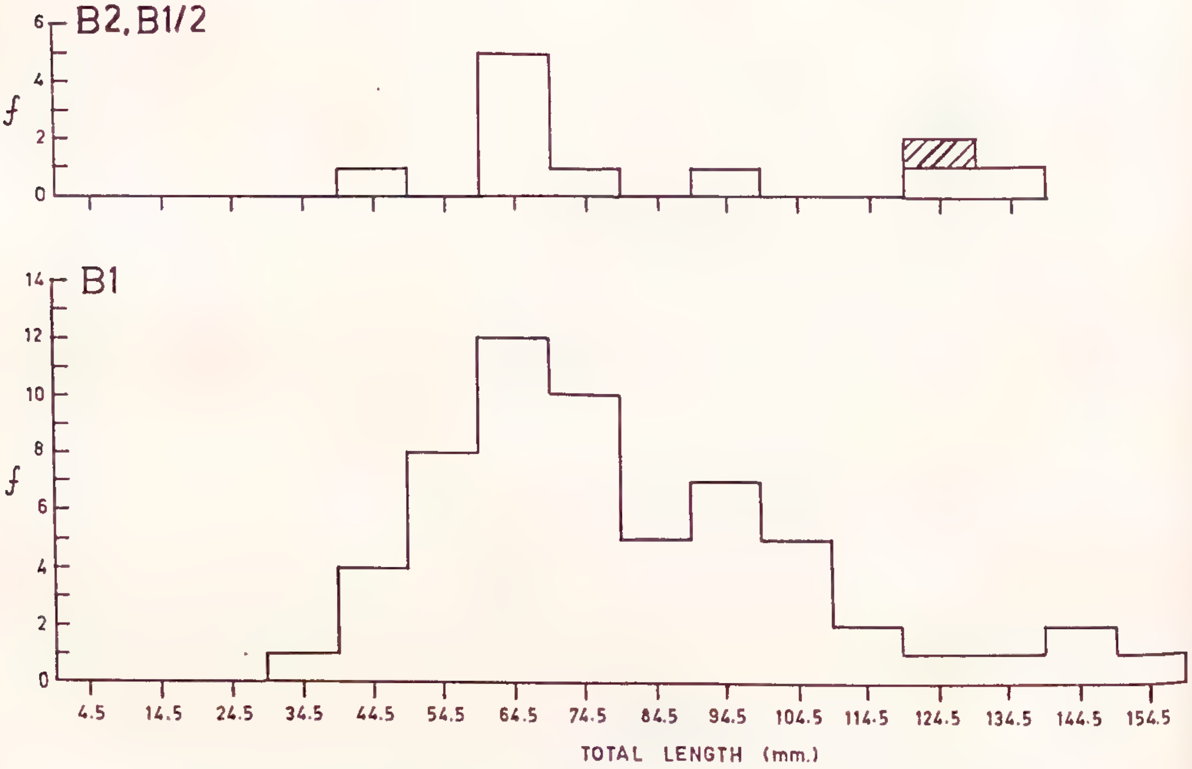


Fig. 7: Frequency histogram of length for Auckland Museum straight *Kuru*

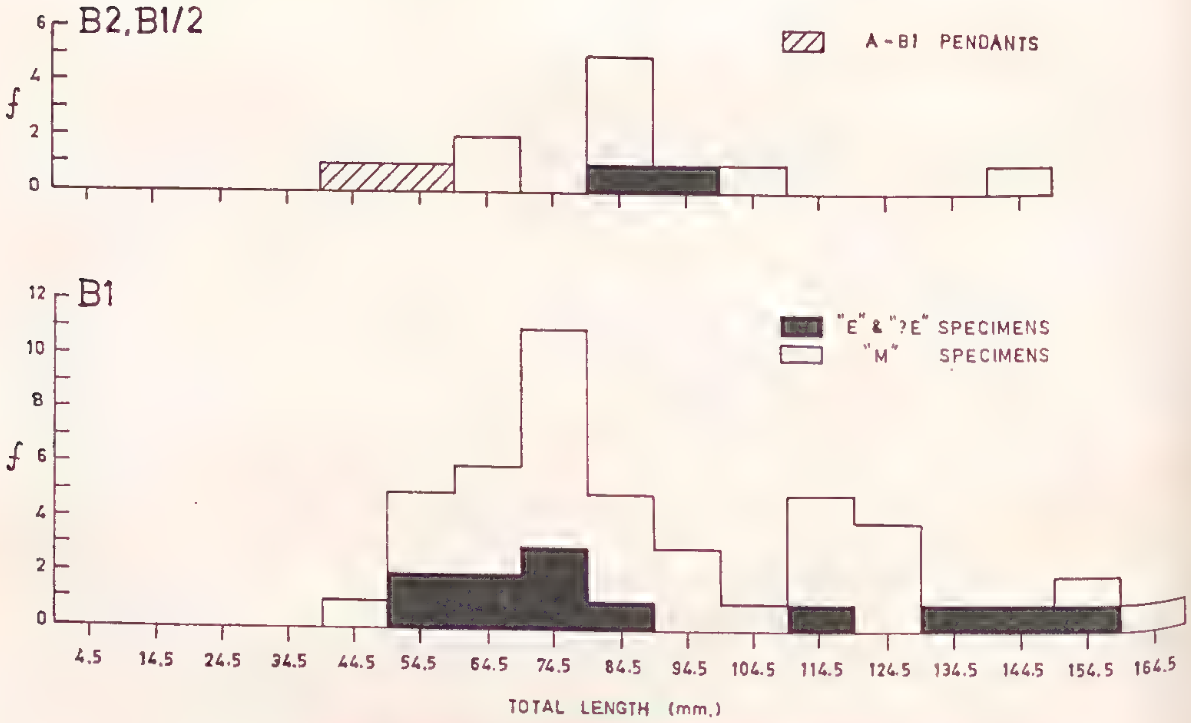


Fig. 8: Frequency histogram of length for Australian Museum straight *Kuru*

Length distribution for Australian Museum pendants is shown in figure 8, where bimodality, with maxima at about 75 and 120 mm, is apparent. In the light of the above comments this feature cannot be explained functionally, and probably should be attributed to sampling bias. The lower limit of pendant length is about 30 mm on both graphs and must be largely technologically determined in that pendants smaller than this were not easy to produce with the equipment available and the manufacturing techniques employed.

Despite the apparent variations in the "M" curves in figures 7 and 8 a crude median splits χ^2 analysis* showed no significant difference between the two samples at $P = 0{\cdot}05$ (see table 4).

TABLE 4. χ^2 ANALYSIS OF B1 "M" PENDANTS FROM SYDNEY AND AUCKLAND

Parameter	χ^2
Length (total)	1·31*
Width (maximum)	8·27‡
$w/t_{(max)}$	0·01*
Perforation diameter	3·95†

* Not significant.
† Significant at $P = 0{\cdot}05$.
‡ Significant at $P = 0{\cdot}01$.

Auckland Museum pendant widths ($w_{(max)}$) are plotted in figure 9 and reveal a negatively-skewed Gaussian with the mode at about 12 mm. As for length, the lower limit of pendant width was determined technologically. The Australian Museum sample differs significantly both visually (figure 10) and statistically (table 4) from the Auckland sample. The mean was calculated as 15·8 (cf. the Auckland value of 12·8 mm). These differences again must be attributed to sampling bias. As expected, a high correlation ($r = +0{\cdot}84$ and $r = +0{\cdot}94$ for Auckland and Australian Museum pendants respectively, both significant at the 0·001 level) was found between maximum width and width at the perforation.

---

*A "median splits" χ^2 analysis is a test whereby the similarity of two histogram shapes can be compared by doing a χ^2 test on the numbers of cases on either side of the median using the median location of the random sample as reference.

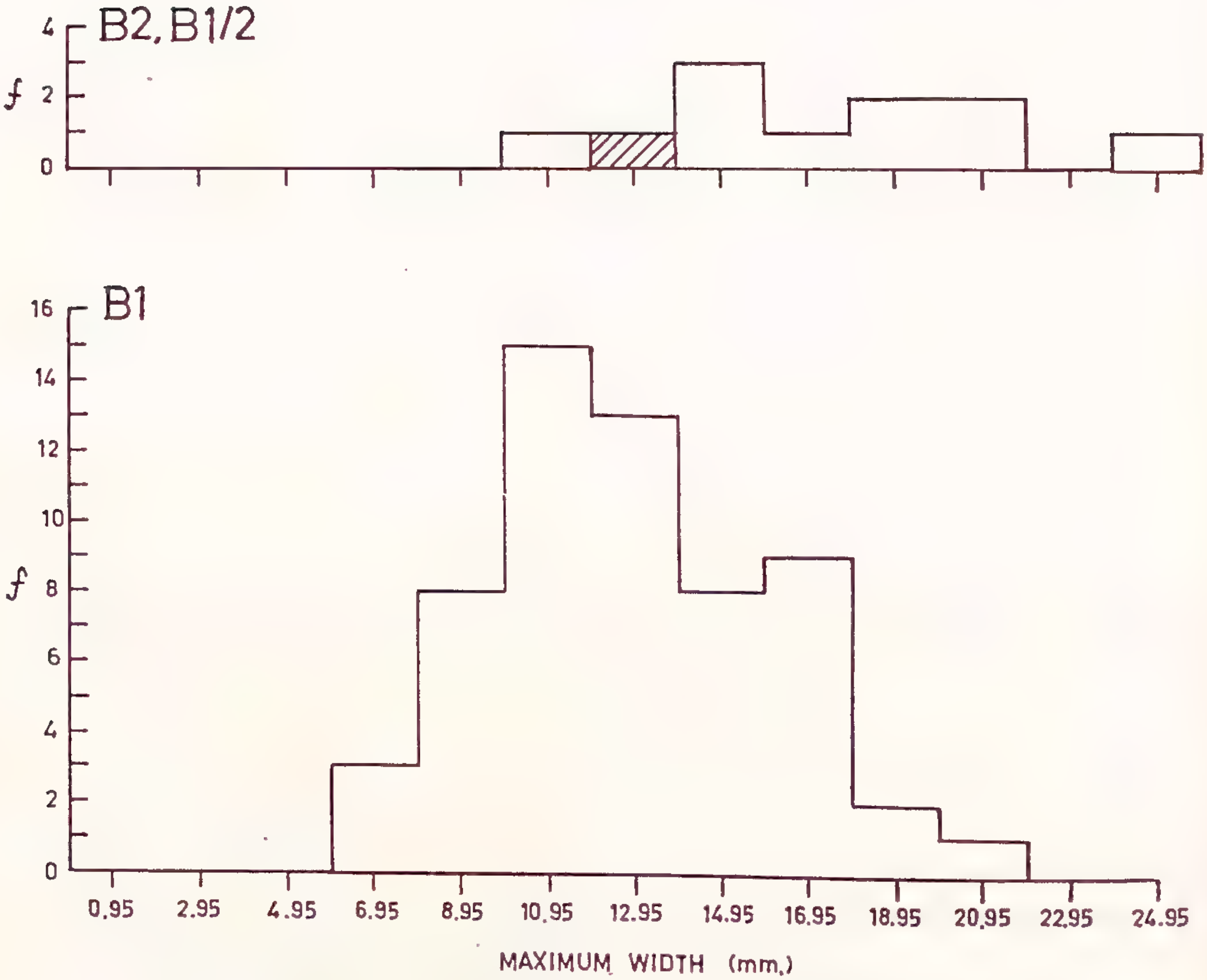


Fig. 9: Frequency histogram of width for Auckland Museum straight *Kuru*

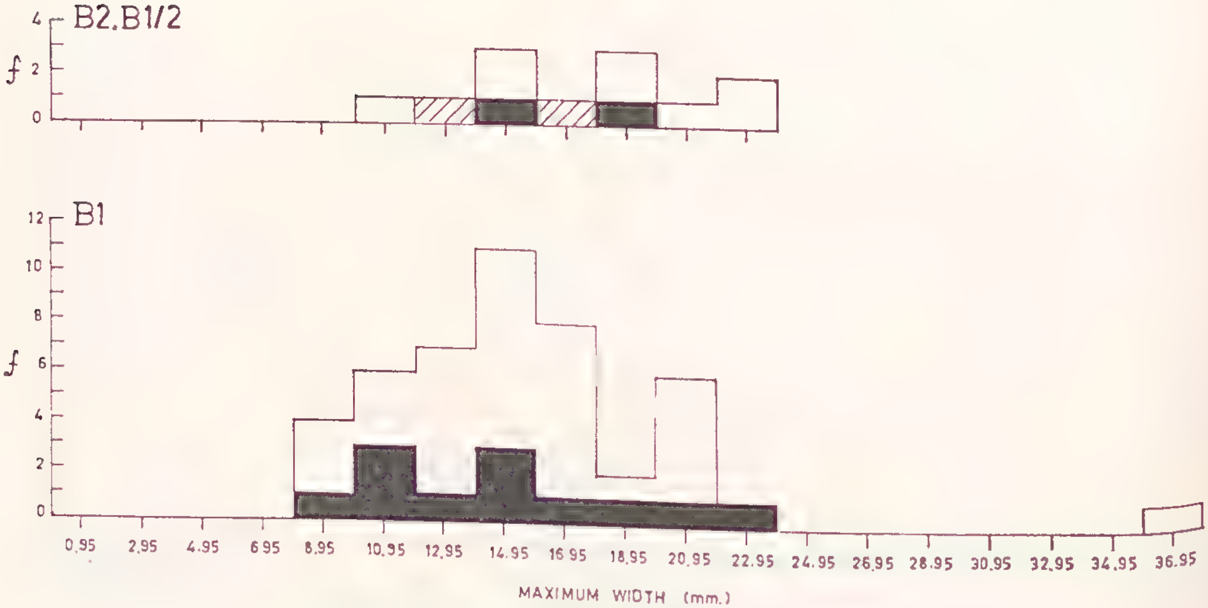


Fig. 10: Frequency histogram of width for Australian Museum straight *Kuru*

No correlation was found for either sample when length was plotted against maximum width (figures 11 and 12). In the latter plot pendant E 54472 (at top right) appears as the only likely metrically-defined neck *kuru*.

In figures 13 and 14 the change in width throughout length is indicated for each pendant by plotting Δw (both $w_{(max)} - w_{(0\cdot66)}$ and $w_{(max)} - w_{(0\cdot33)}$ separately) against maximum width. It can be seen that although very few pendants are parallel-sided (i.e. $\Delta w = 0$) many show only a small deviation. In both samples there is a general trend towards greater variation in width with increasing maximum width.

Figures 15 and 16 show maximum width plotted against thickness (at maximum width) for each pendant. No correlation was found at $P = 0\cdot05$ for either sample.

Width/thickness ratios (w/t) give a numerical indication of the major and minor axes of pendants at three different locations. In figures 17 and 18 maximum width has been plotted against $\Delta w/t$ (both $w/t_{(max)} - w/t_{(0\cdot66)}$ and $w/t_{(max)} - w/t_{(0\cdot33)}$) to show that most pendants exhibit little change in cross-section throughout their lengths (i.e. $\Delta w/t \rightarrow 0$), and where variations do occur these are irrespective of maximum width.

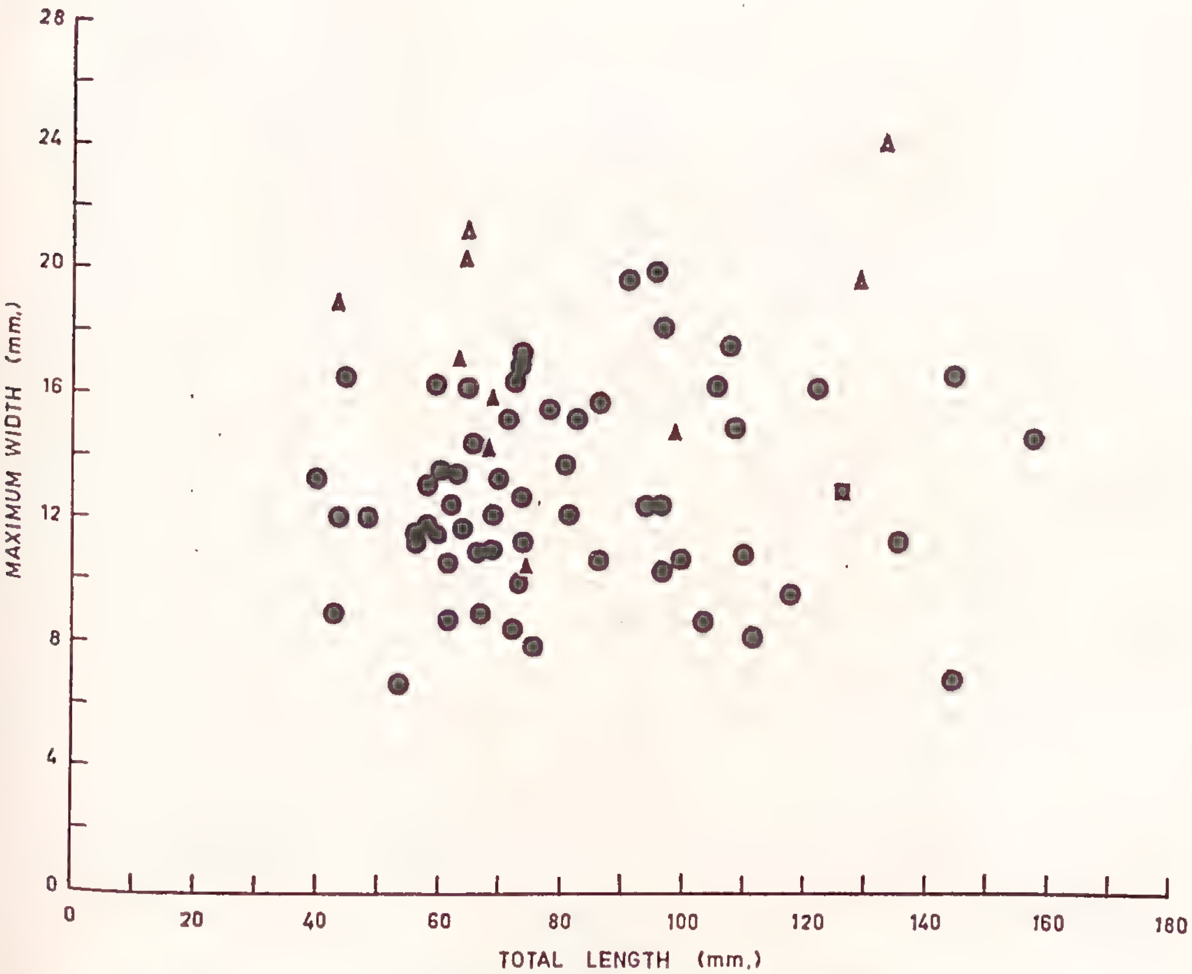


Fig. 11: Scatter diagram of length vs width for Auckland Museum straight *Kuru*

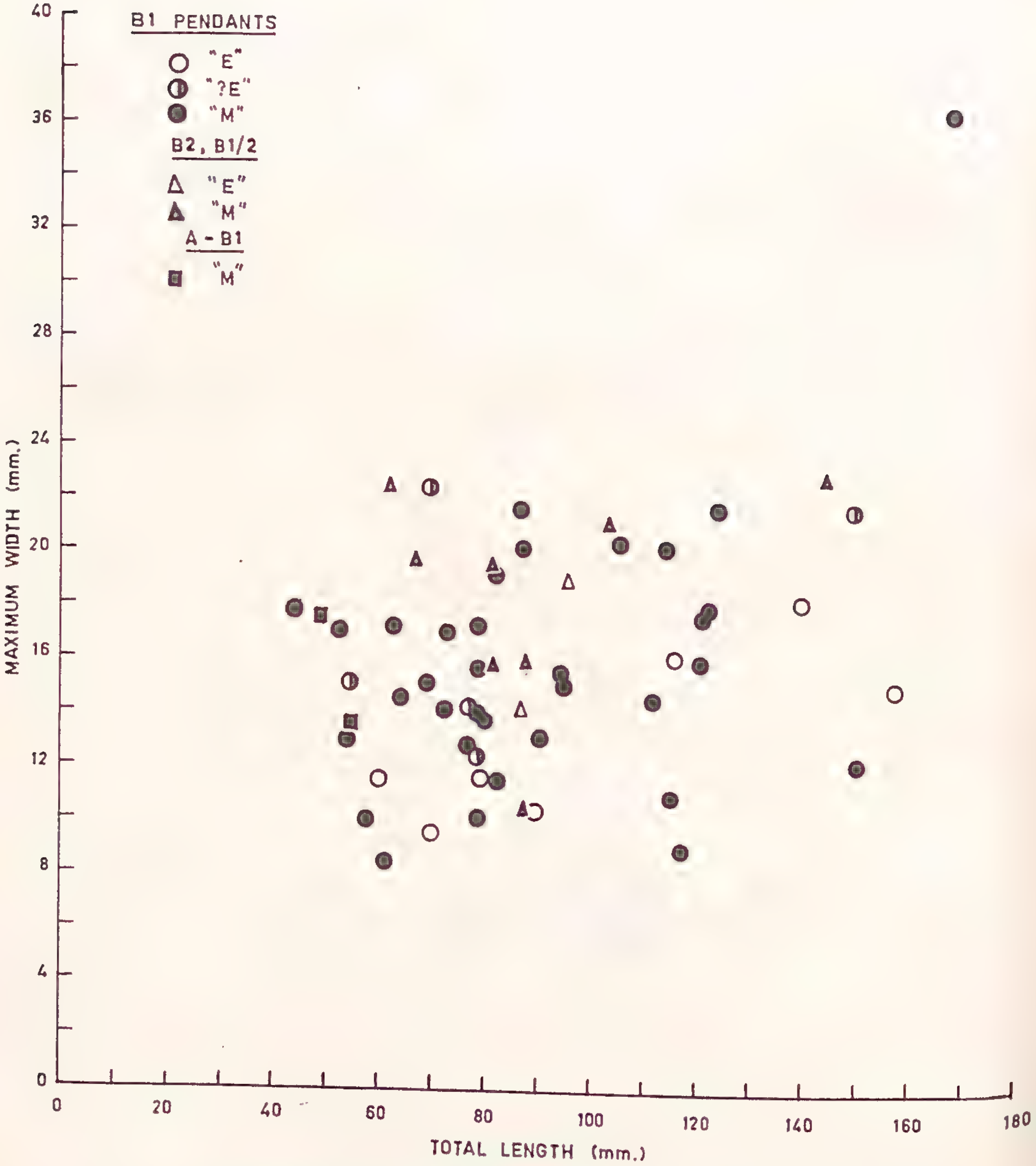


Fig. 12: Scatter diagram of length vs width for Australian Museum straight *Kuru*

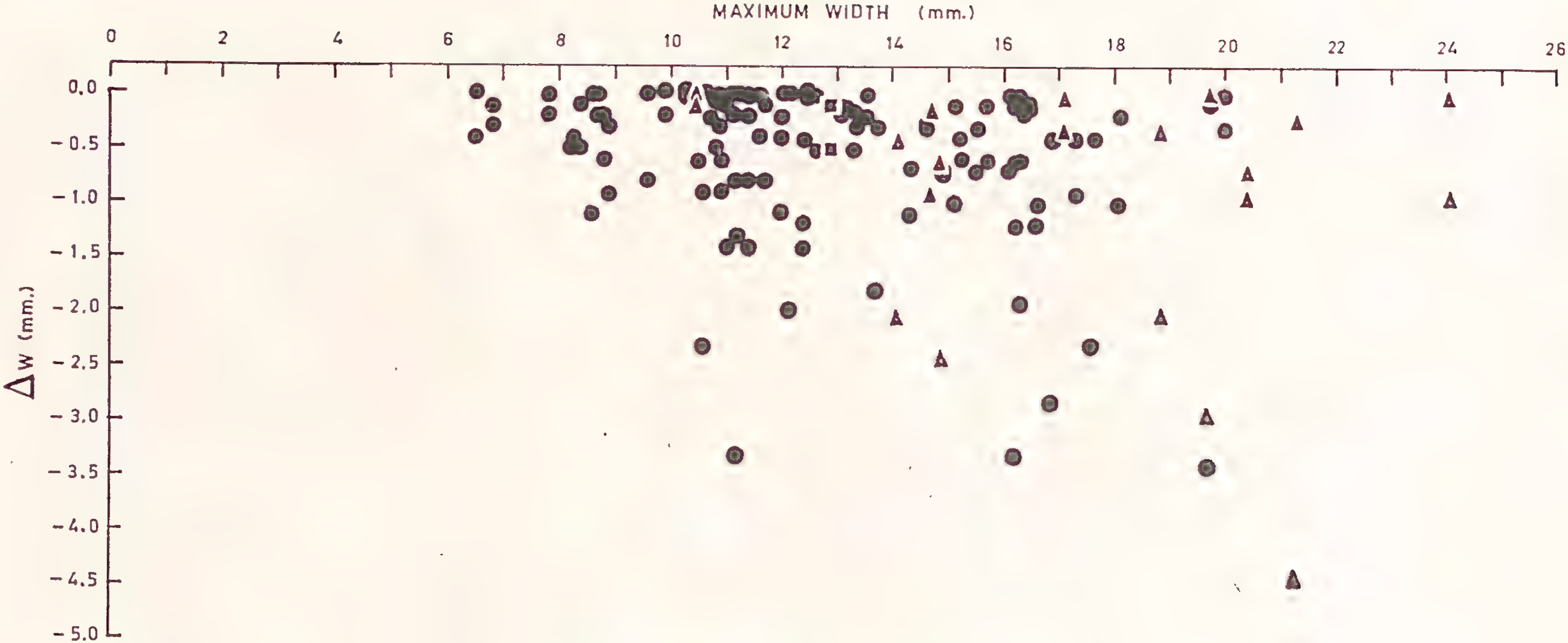


Fig. 13: Plot of Δw vs width for Auckland Museum straight *Kuru*

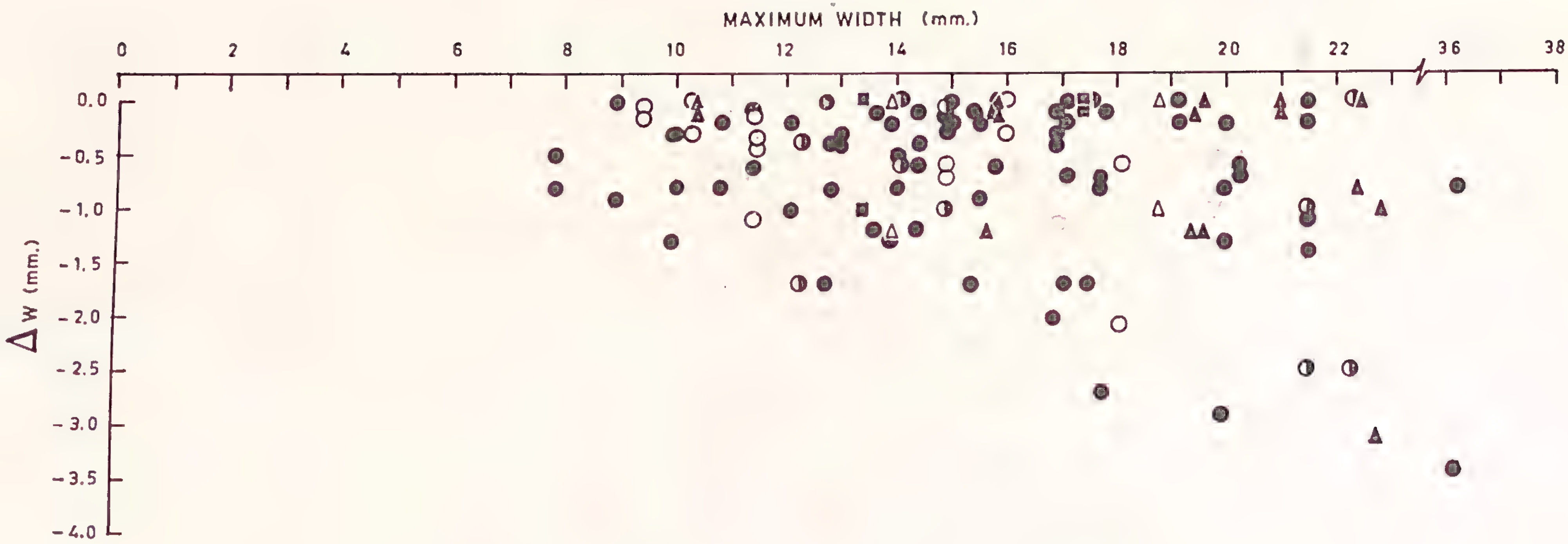


Fig. 14: Plot of Δw vs width for Australian Museum straight *Kuru*

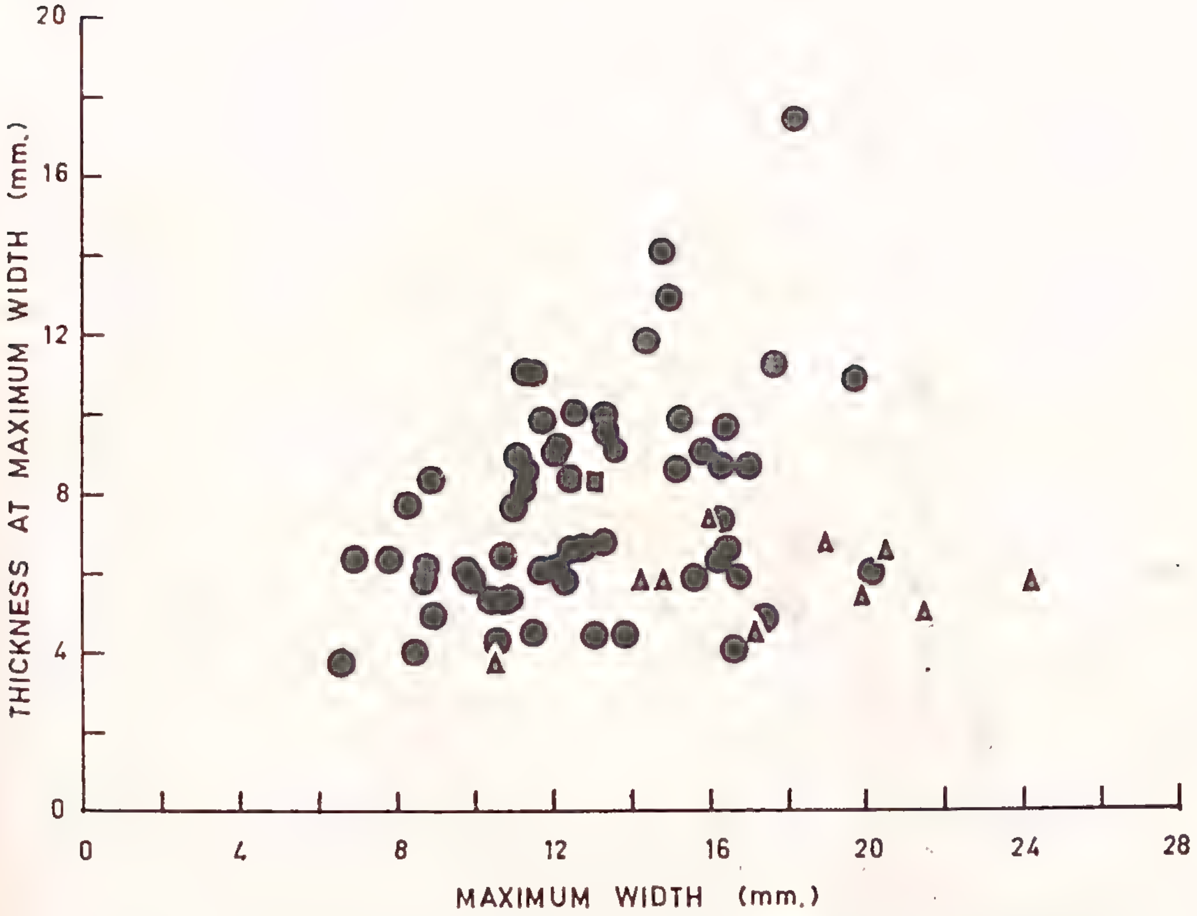


Fig. 15: Scatter diagram of thickness vs width for Auckland Museum straight *Kuru*

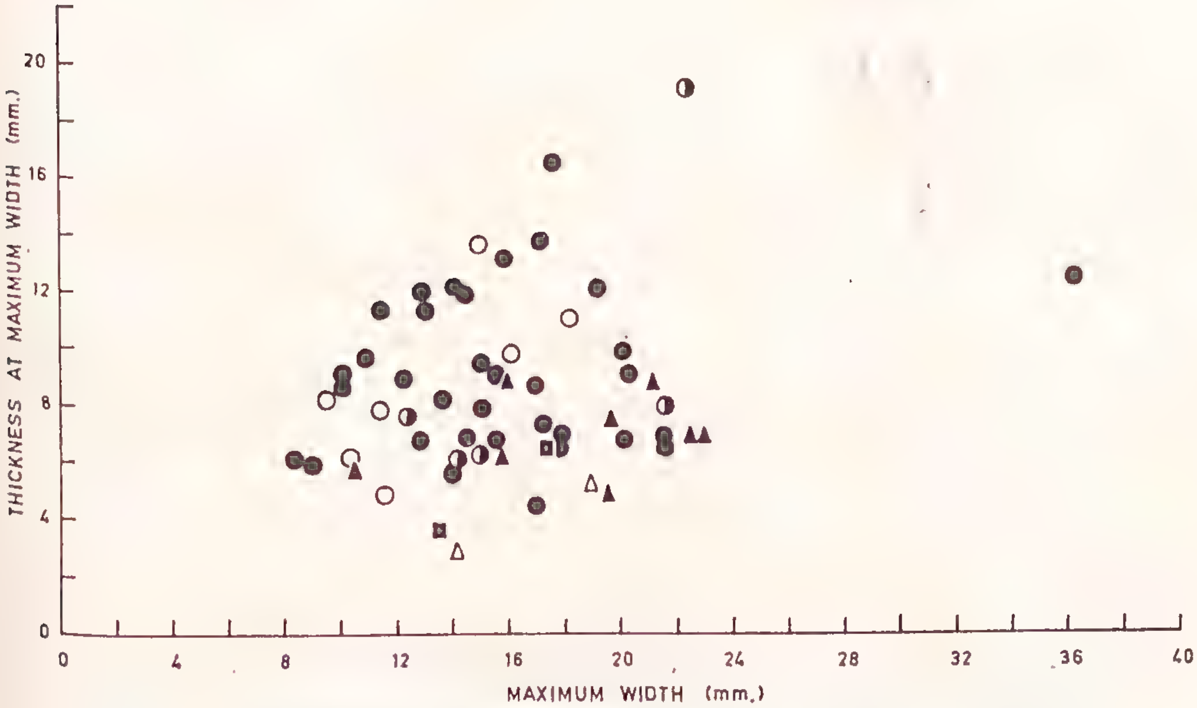


Fig. 16: Scatter diagram of thickness vs width for Australian Museum straight *Kuru*

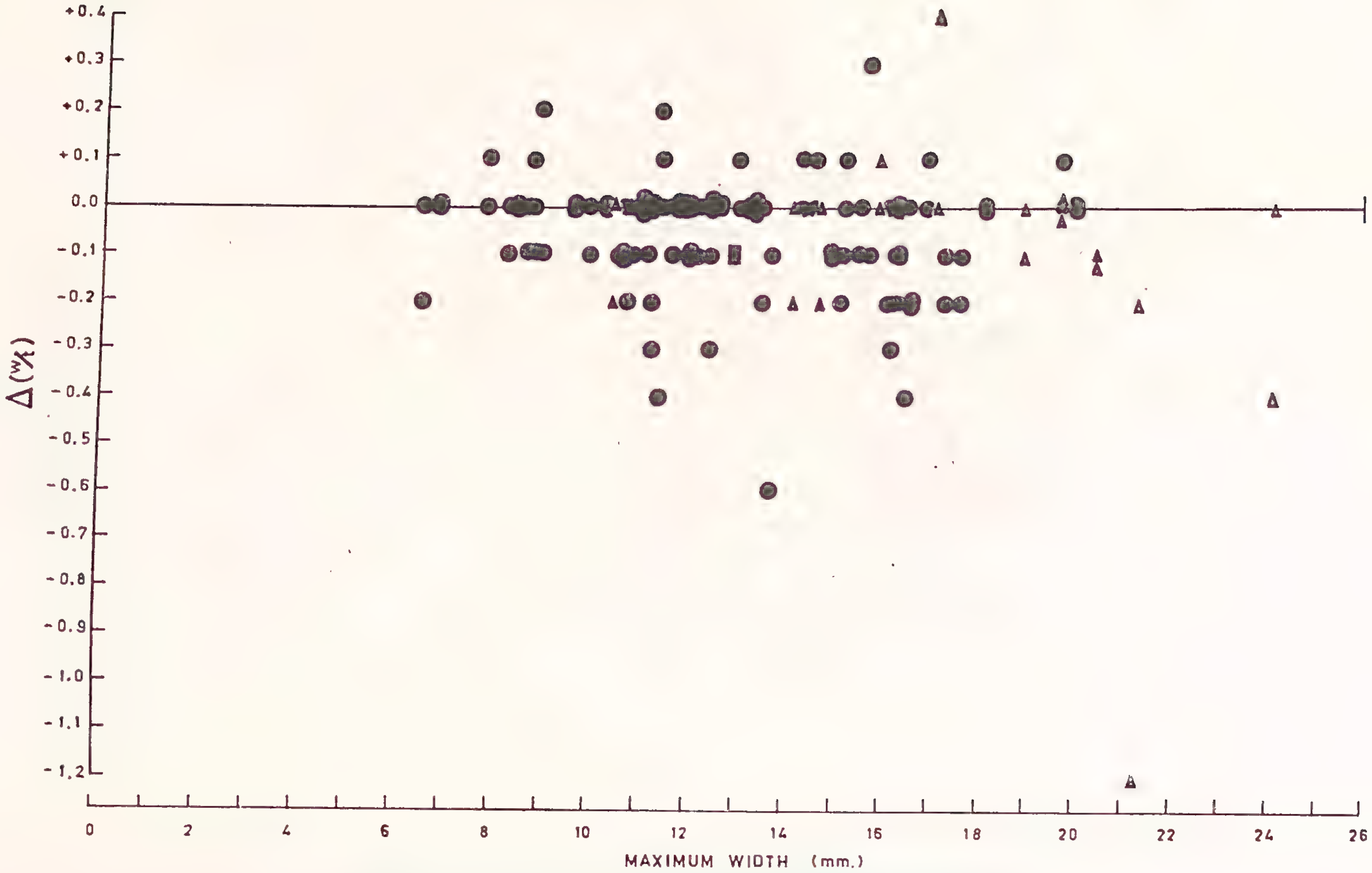


Fig. 17: Plot of $\Delta w/t$ vs width for Auckland Museum straight *Kuru*

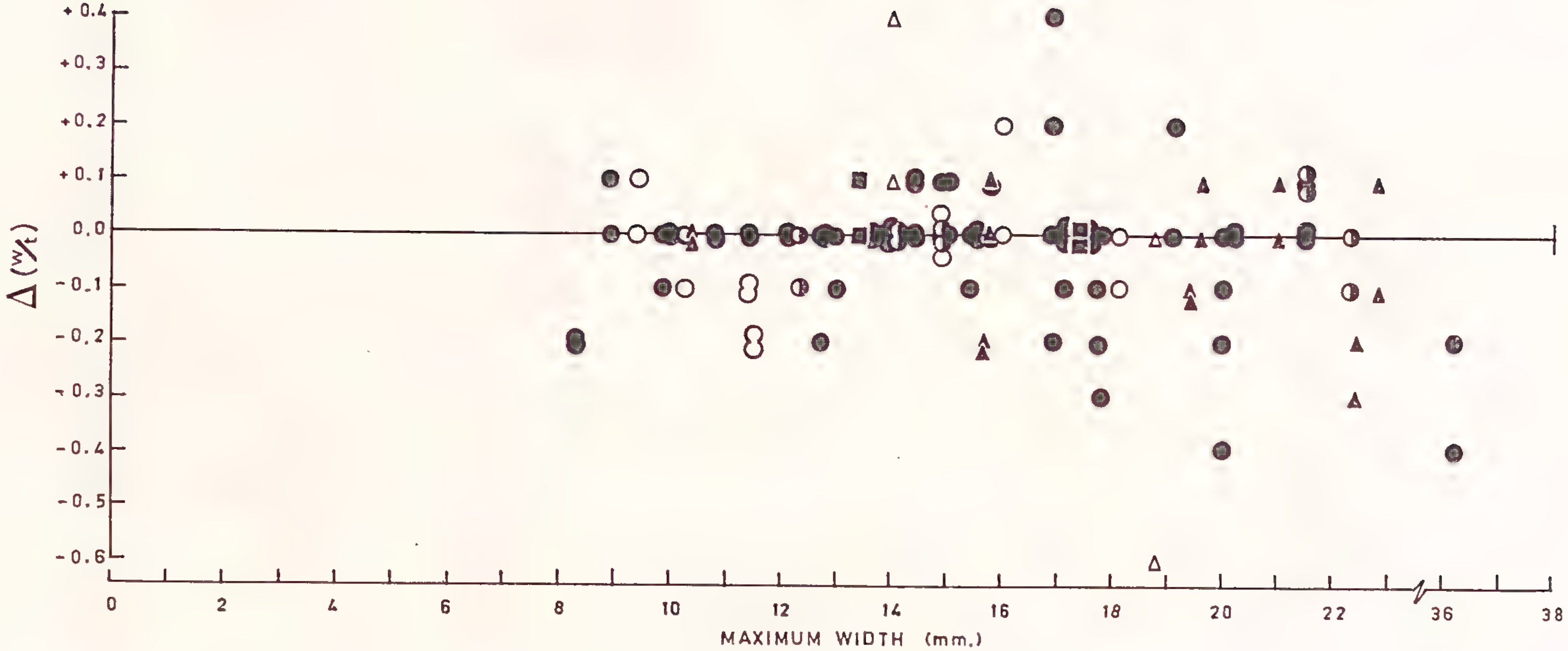


Fig. 18: Plot of $\Delta w/t$ vs width for Australian Museum straight *Kuru*

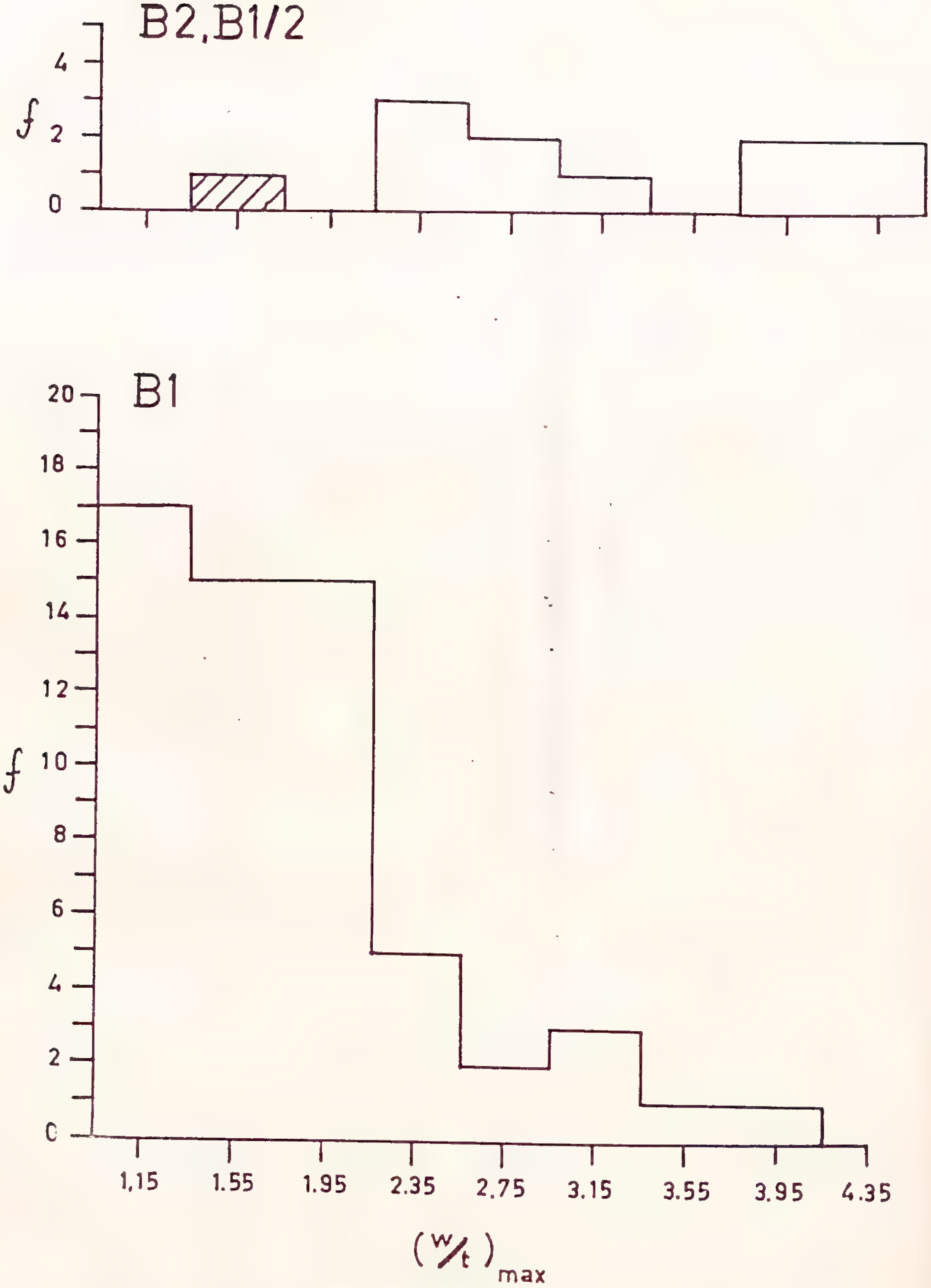


Fig. 19: Frequency histogram of *w*/*t* for Auckland Museum straight *Kuru*

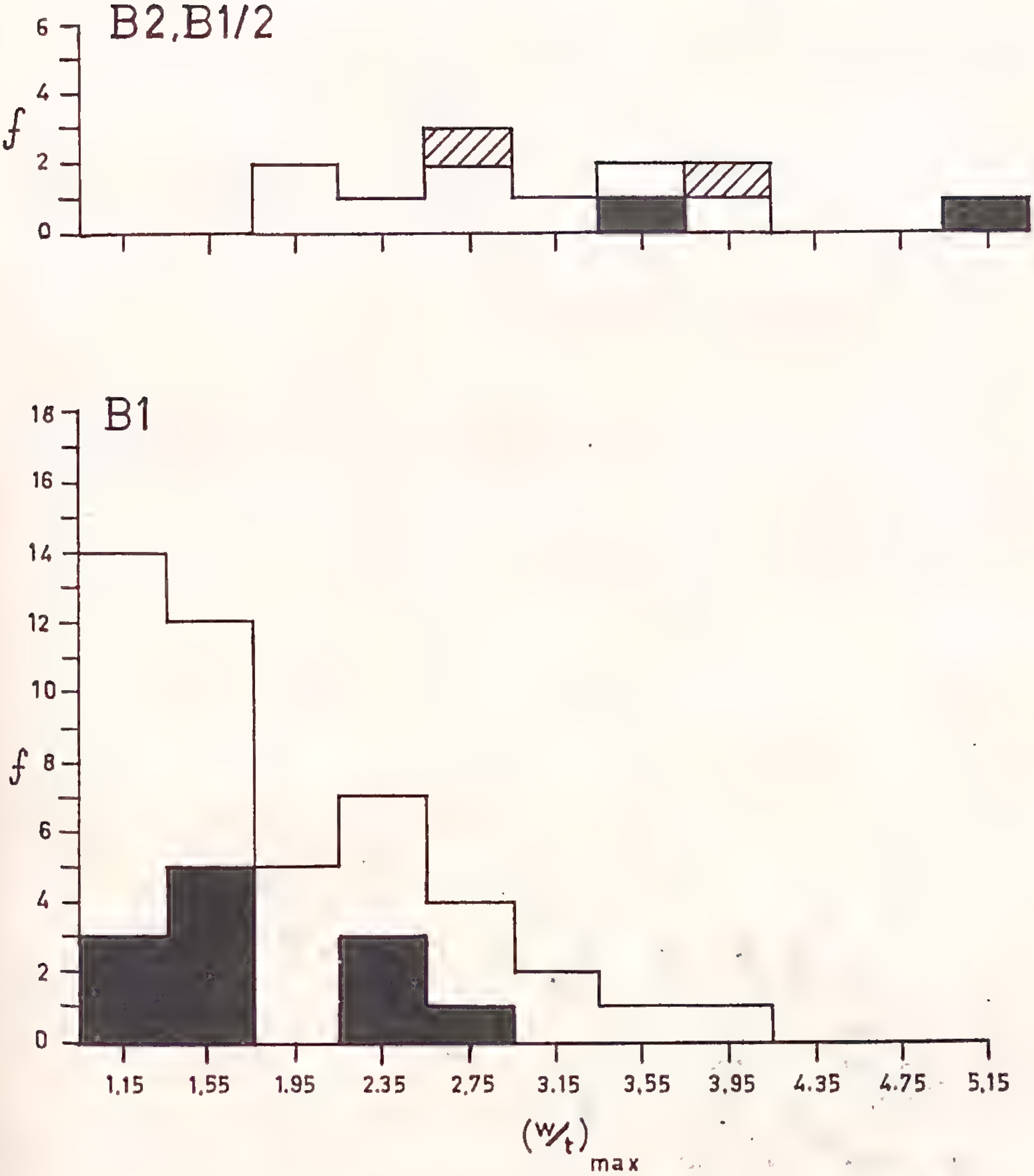


Fig. 20: Frequency histogram of *w/t* for Australian Museum straight *Kuru*

Having established that there is little change in pendant cross-sections at the three positions measured, figures 19 and 20 give histograms of $w/t_{(max)}$. Despite the differing one-tailed Gaussian fits a median splits χ^2 analysis failed to show any significant difference between the two samples at $P = 0{\cdot}05$.

In figures 21 and 22 $w/t_{(max)}$ is plotted against maximum width; correlations exist for both samples ($r = +0{\cdot}39$ and $+0{\cdot}62$ respectively, significant at $P = 0{\cdot}01$ and $P = 0{\cdot}001$). This suggests that with the manufacturing techniques at their disposal and implements available the Maoris generally found it difficult to produce narrow pendants with anything other than near-circular cross-sections.

In that pendant suspension perforations are functional their sizes and positioning should have been influenced not only by cultural norms but also by some of the variables discussed above.

Figure 23 shows a frequency histogram of internal perforation diameter where a positively-skewed Gaussian with a mode at about 3·7 mm is represented. This differs markedly (see table 4) from the Australian Museum plot, a negatively-skewed Gaussian, in figure 24. The abrupt lower cut-off points on both graphs reflect technological and functional factors: that holes of smaller diameter were not easily produced with Maori drills, but even if they were they would have been too small to permit passage of even the finest native cordage.

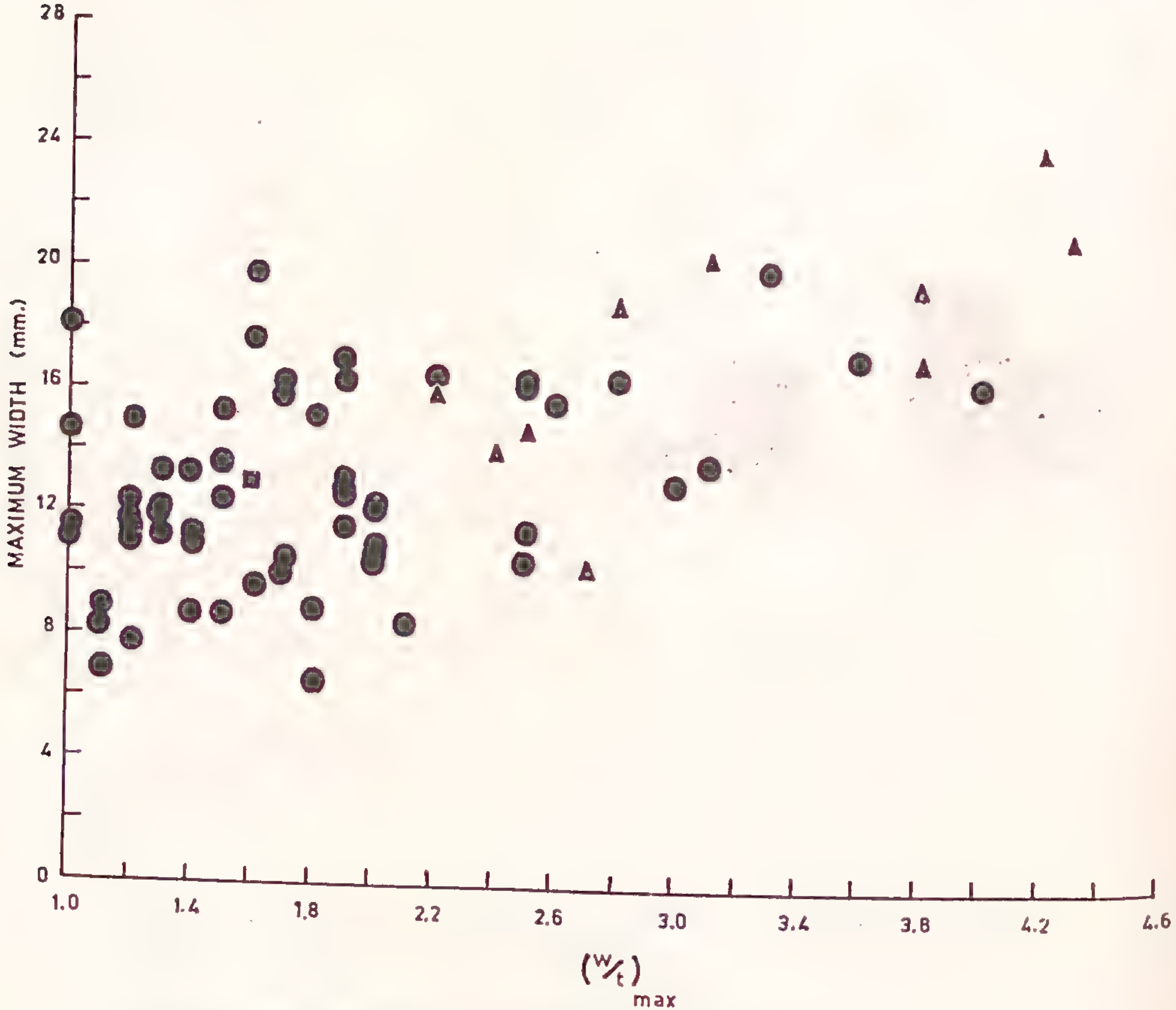


Fig. 21: Scatter diagram of *w/t* vs width for Auckland Museum straight *Kuru*

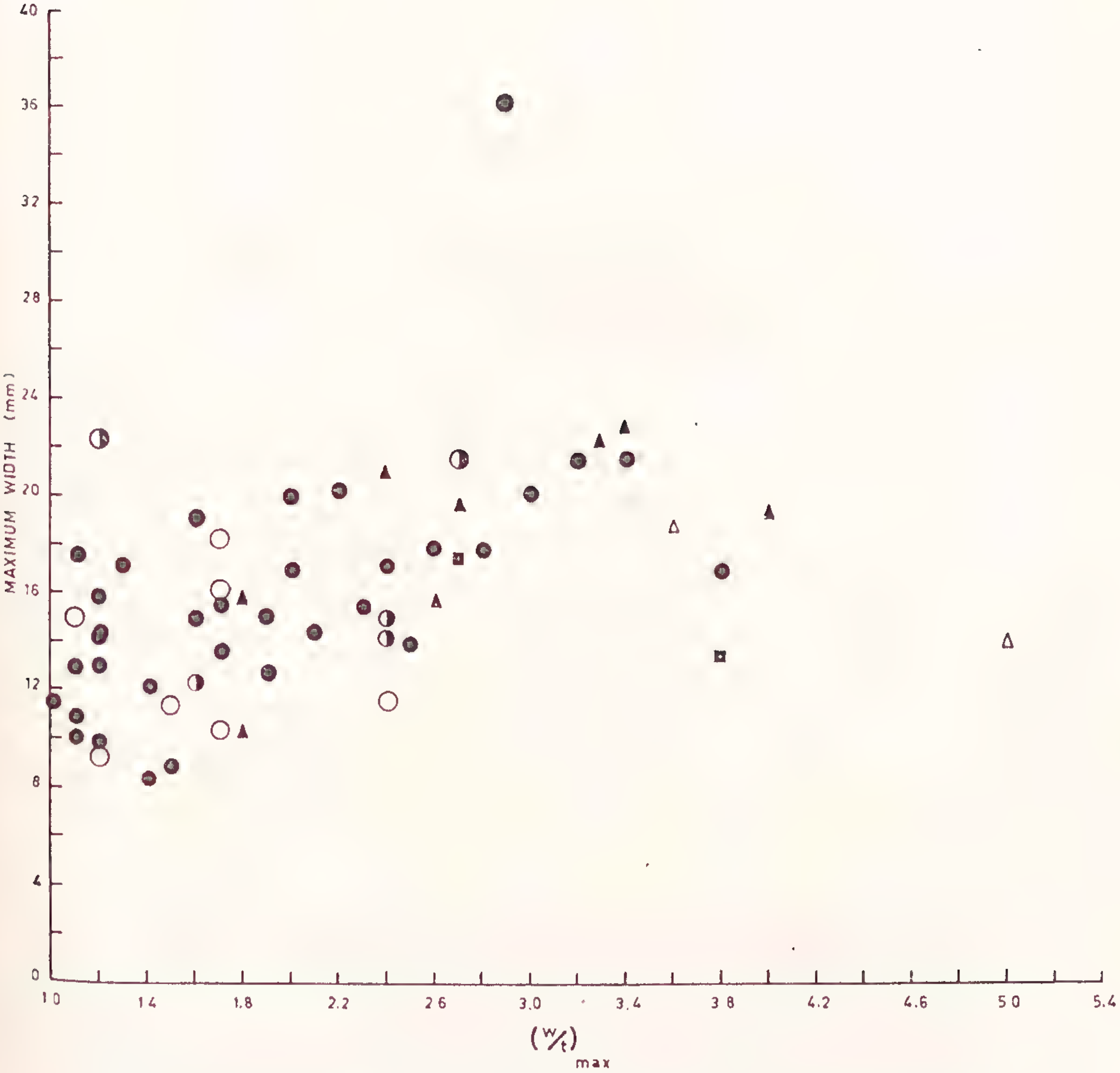


Fig. 22: Scatter diagram of *w*/*t* vs width for Australian Museum straight *Kuru*

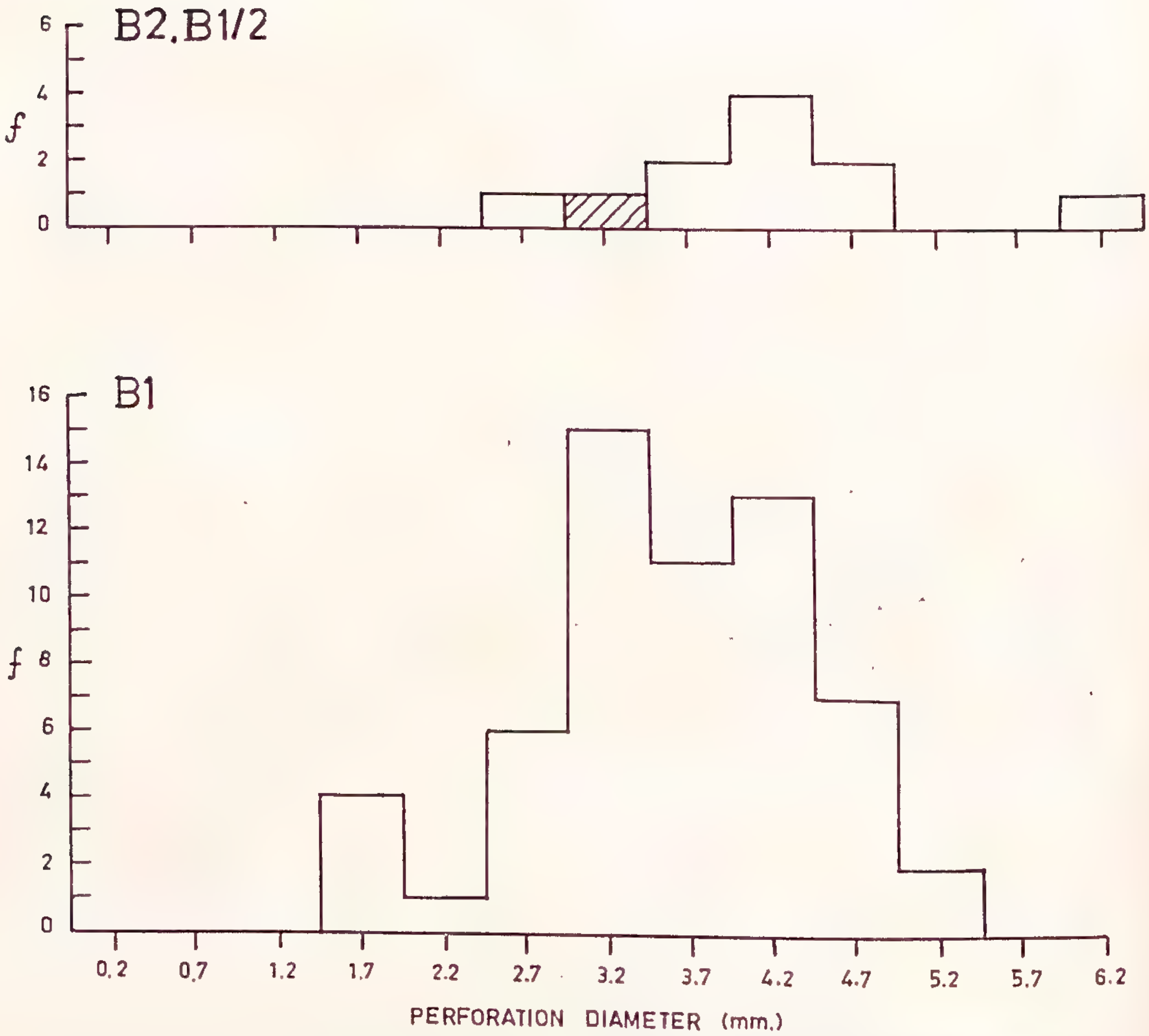


Fig. 23: Frequency histogram of perforation diameter for Auckland Museum straight *Kuru*

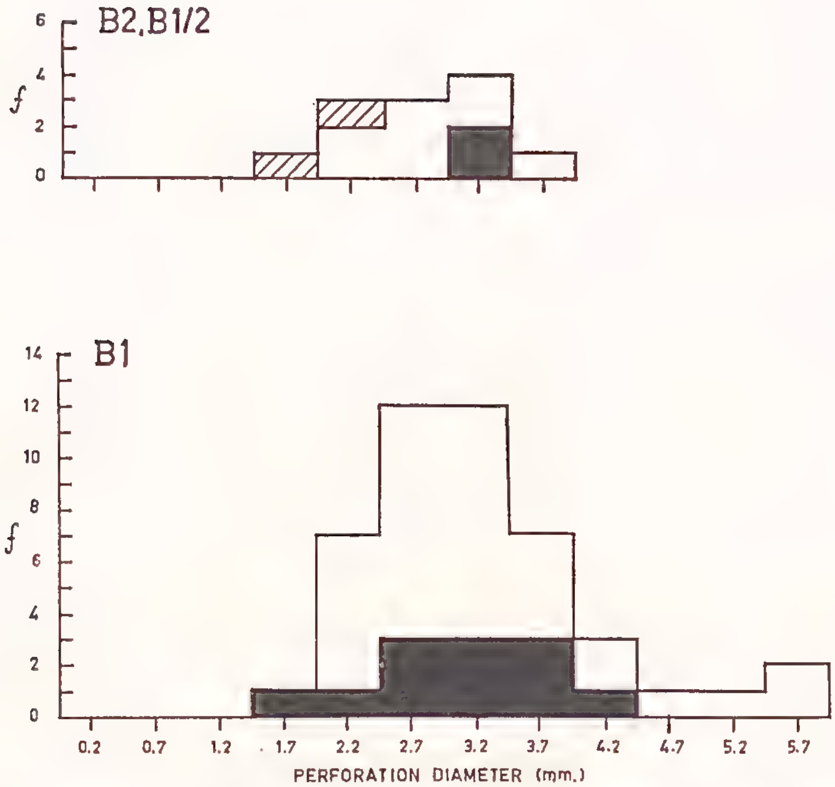


Fig. 24: Frequency histogram of perforation diameter for Australian Museum straight *Kuru*

Perforation diameter has been plotted against maximum width in figures 25 and 26. In the former there is a vague suggestion that perforation diameter increases lineally with width until $w_{(max)}$ reaches about 12 mm and then levels off, remaining predominantly between 3 and 5 mm. No such correlation is hinted at in the Australian Museum scatter diagram.

Figures 27 and 28 show perforation diameter plotted against butt to perforation length. Linear correlations of $r = +0{\cdot}52$ and $+0{\cdot}48$ (significant at $P = 0{\cdot}001$ and $P = 0{\cdot}01$, respectively) were calculated. Butt to perforation length was not found to be correlated with total pendant length.

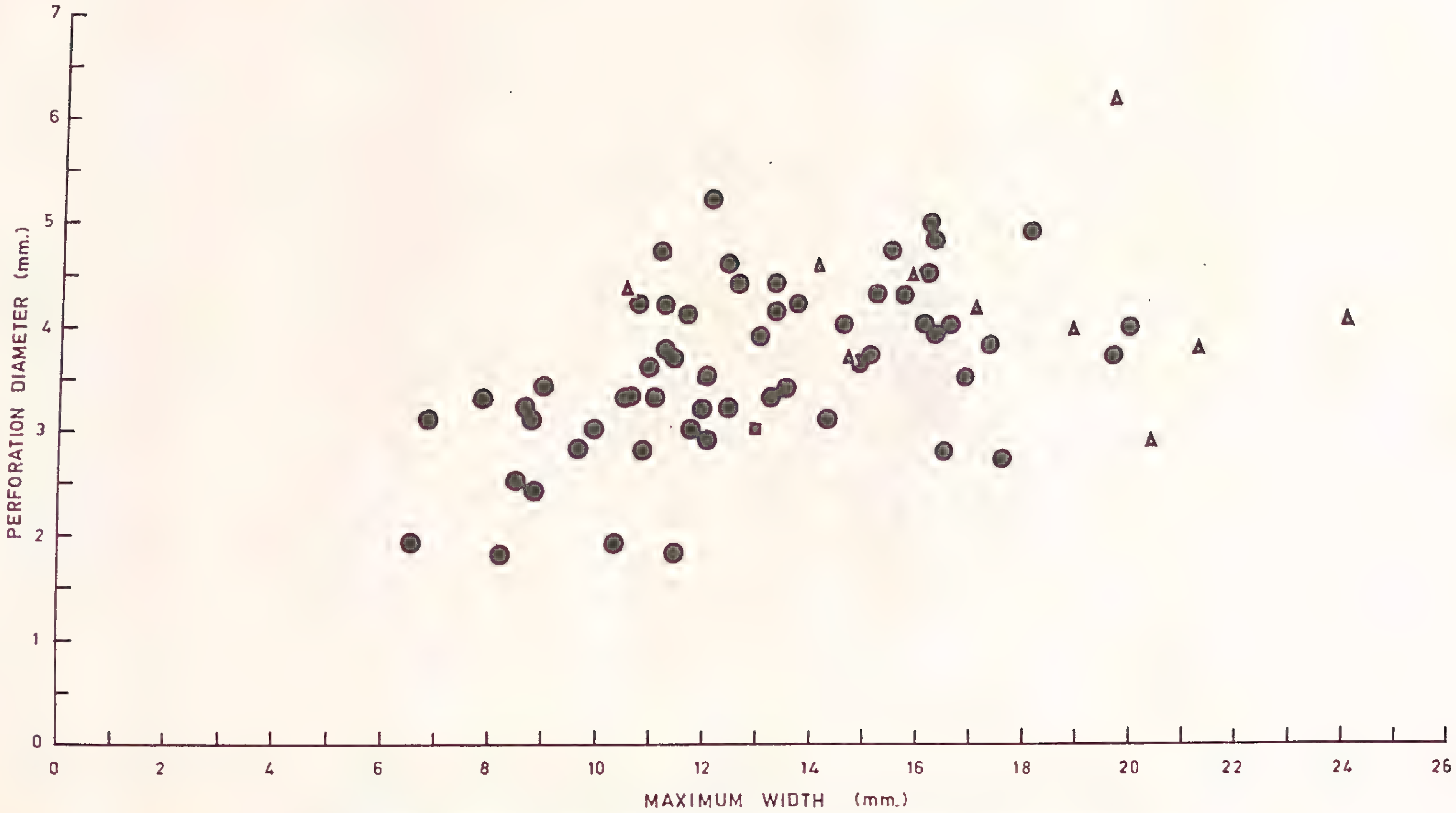


Fig. 25: Scatter diagram of perforation diameter vs width for Auckland Museum straight *Kuru*

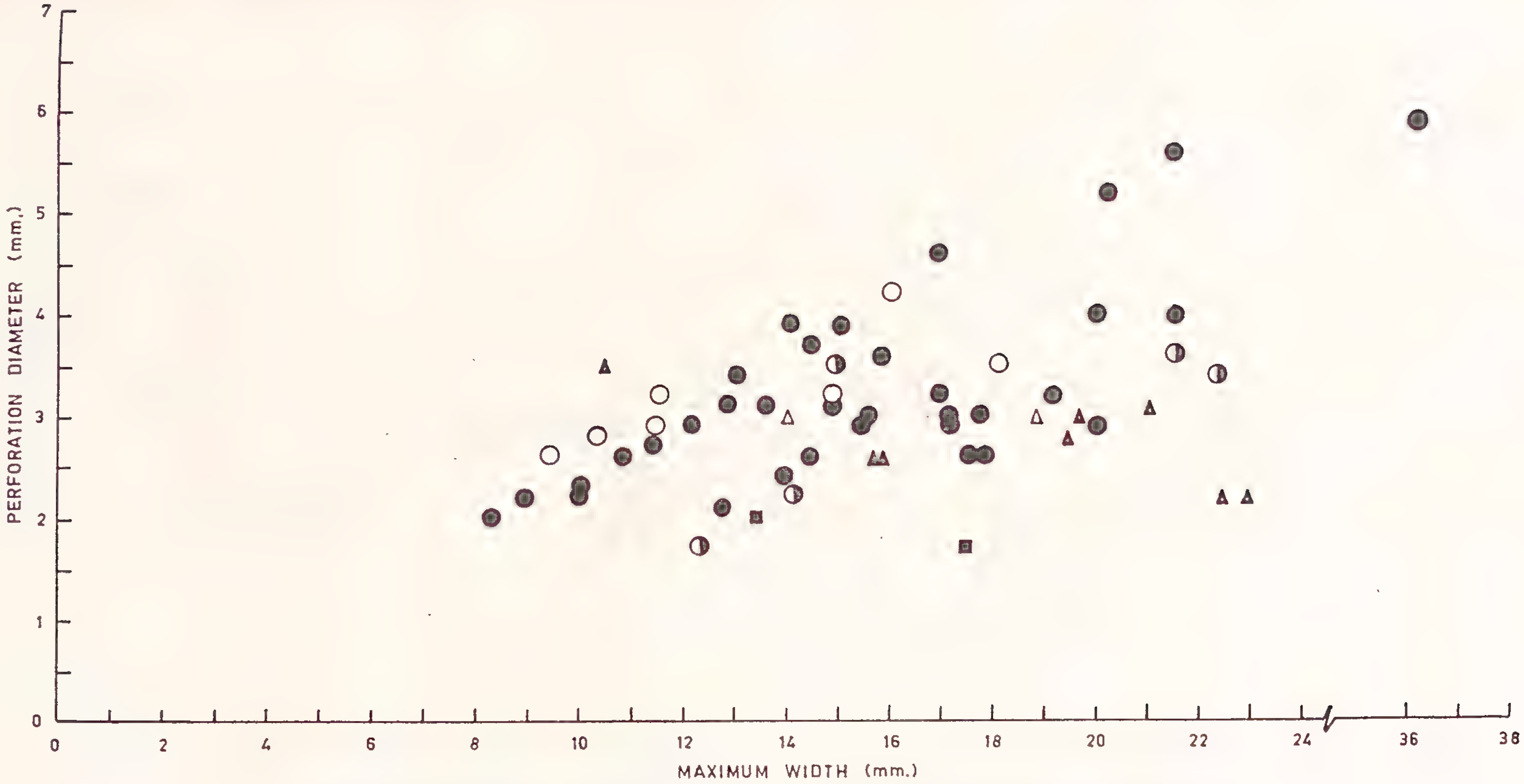


Fig. 26: Scatter diagram of perforation diameter vs width for Australian Museum straight *Kuru*

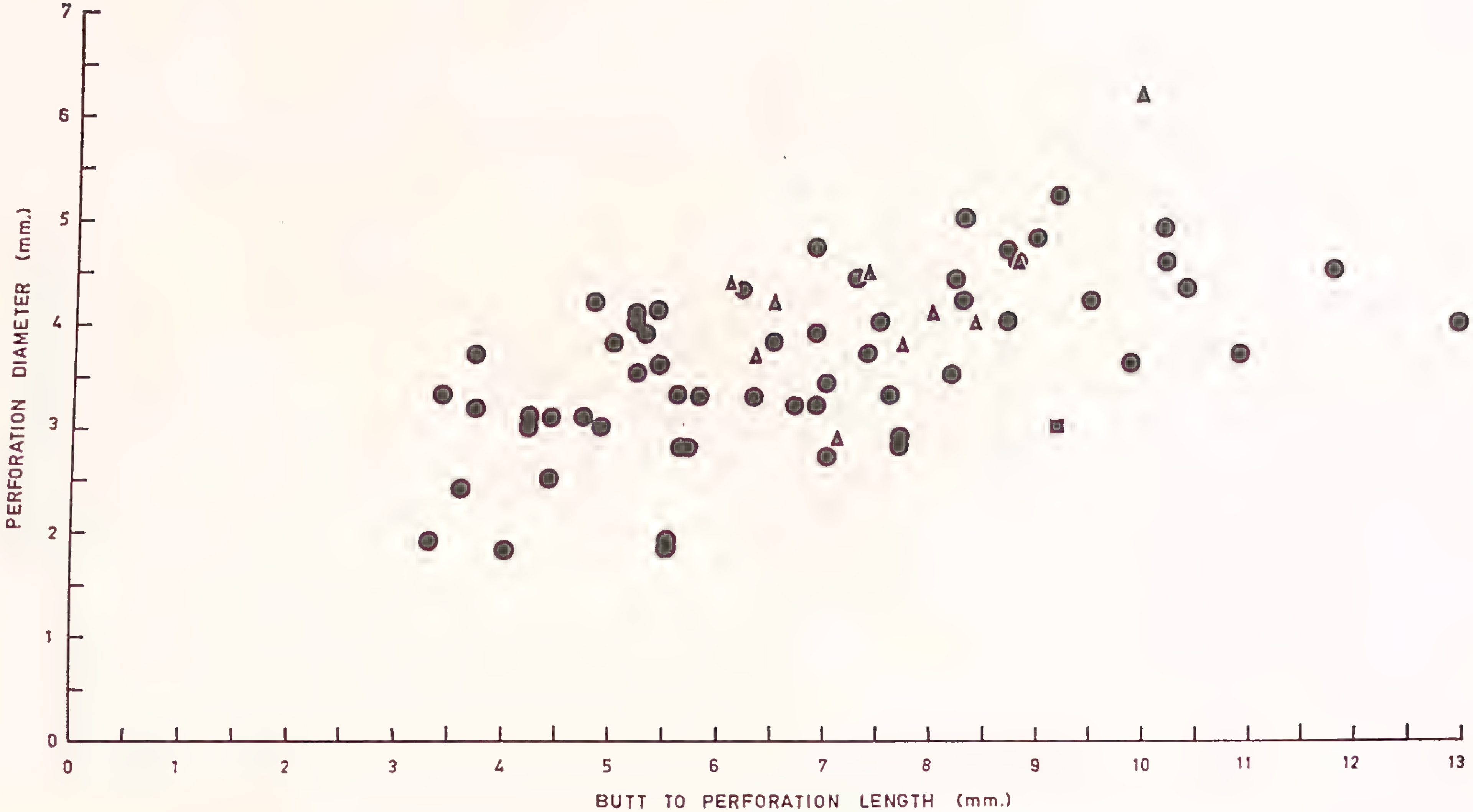


Fig. 27: Scatter diagram of perforation diameter vs butt-perforation length for Auckland Museum straight *Kuru*

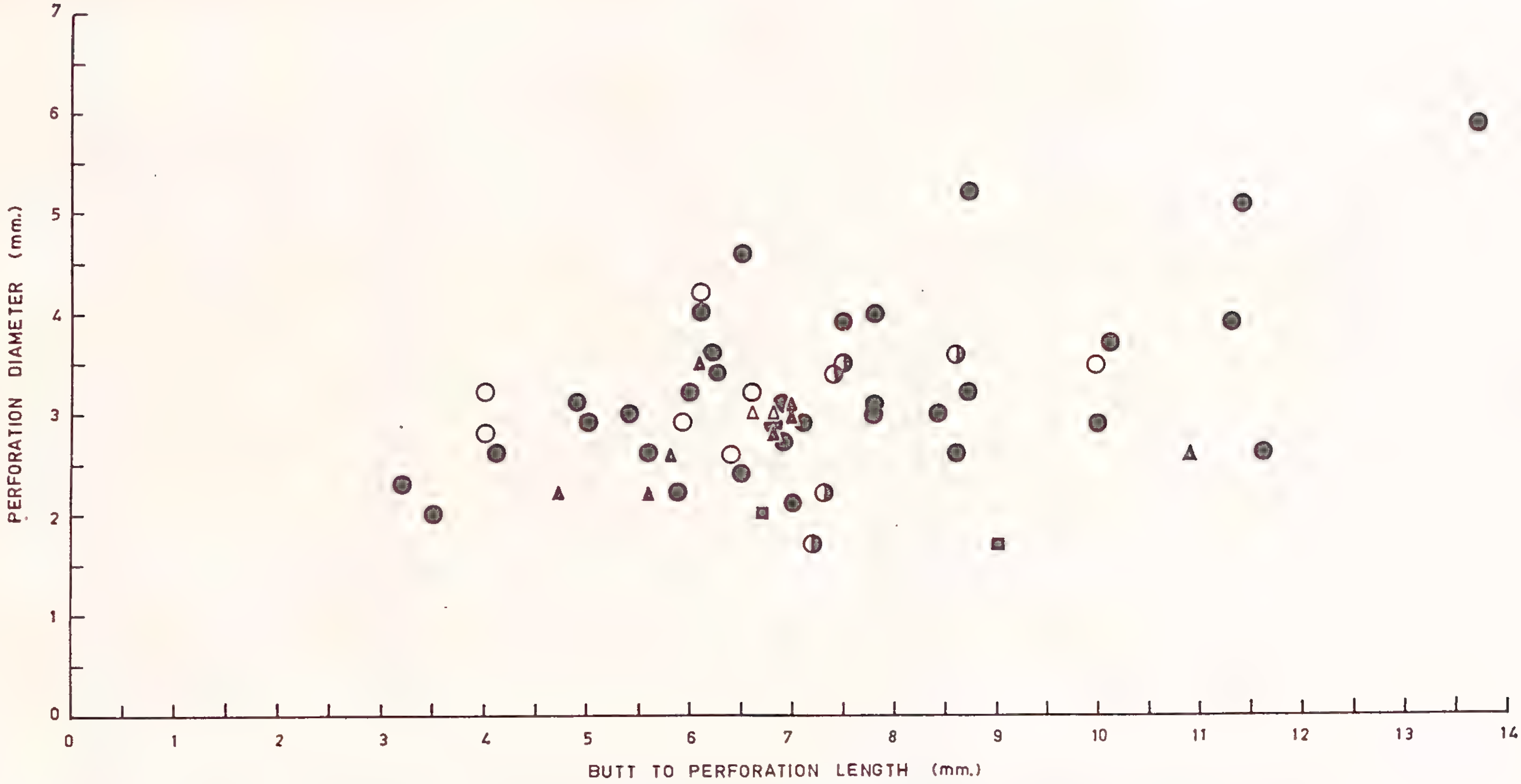


Fig. 28: Scatter diagram of perforation diameter vs butt-perforation length for Australian Museum straight *Kuru*

Finally, occurrence frequencies of various distal end forms exhibited by the different cross-sectional types are listed in table 5. The Auckland and Australian Museum samples do not differ significantly at P = 0·05.

TABLE 5. DISTRIBUTION OF DISTAL END SHAPES IN TWO SAMPLES OF B1 "M" PENDANTS

Distal shape	Sydney	Auckland
R	0	1
C	5	14
E	9	13
P	17	19
H	3	12

The above investigations have revealed several differences between the Sydney and Auckland samples to the extent that the former cannot be regarded as random. This is due to bias in the geographical or chronological distribution of these pendants; both factors may be relevant.

Some 35 per cent of the B1 straight *kuru* in the Australian Museum are of the "E" or "?E" category, and have been represented in the foregoing histograms and scatter diagrams. Median splits χ^2 analyses of combined "E-?E" specimens in figures 8, 10, 20, and 24 and corresponding Australian and Auckland Museum "M" pendants are given in table 6. The "E-?E" specimens do not differ significantly from either of the two "M" samples. However, this is not the case in some of the scatter diagrams (figures 12 and 26), where "E" pendants alone revealed statistically significant correlations (see table 7). Moreover, the correlations found for "M" pendants in figures 22 and 28 were not reflected by "E" specimens, whilst "?E" pendants do not show correlations in any of the scatter plots. Despite these differences "E-?E" pendants should generally be seen as successful reproductions of a protohistorically-defined conceptualised type.

TABLE 6. χ^2 ANALYSIS OF SYDNEY B1 "E-?E" PENDANTS AND B1 "M" SPECIMENS FROM SYDNEY AND AUCKLAND

Parameter	χ^2	
	Sydney	Auckland
Length (total)	0·38 *	0·065*
Width (maximum)	0·005*	1·53 *
$w/t_{(max)}$	0·23 *	0·20 *
Perforation diameter	0·04 *	1·86 *

* Not significant.

B2 and hybrid B1/2 specimens are mere varieties of the B subtype and hence, in general, should not differ markedly from B1 pendants. This is borne out in the scatter diagrams where B2, B1/2 correlations for Auckland and Australian Museum specimens correspond to those found for B1 pendants (see table 7), except in the case of figure 28. Because of their distinctive cross-sectional forms B2, B1/2 pendants are indistinguishable from B1 specimens at low *w/t* values, hence the expected differences in figures 19 and 20 (see also table 8). In view of these *w/t* ratios, and the correlations shown in figures 21 and 22 (cf. table 7), the differences observable in figure 9 (cf. table 8) are to be expected.

TABLE 7. CORRELATION COEFFICIENTS FOR PLOTTED SCATTER DIAGRAMS

Plot	Sydney B1			Sydney B1/2, B2	Auckland B1	Auckland B1/2, B2
	"M"	"E"	"?E"	"M"	"M"	"M"
Length (total) vs width (maximum)	...	+0·82*	...	...	...	...
Thickness (at $w_{(max)}$) vs width (maximum)	...	...	...	...	...	...
$w/t_{(max)}$ vs width (maximum)	+0·62‡	...	...	+0·69*	+0·39†	+0·74†
Width (perforation) vs width (maximum)	+0·94‡	+0·93†	+0·98†	+0·84†	+0·84‡	+0·76†
Perforation diameter vs width (maximum)	...	+0·79*	...	...	*n*	...
Length (butt to perforation) vs length (total)	...	...	...	...	...	...
Perforation diameter vs length (butt-perf.)	+0·48†	...	...	...	+0·54‡	+0·64*

... No correlation.

n ?Non-linear correlation.

* Correlation at $P = 0·05$.

† Correlation at $P = 0·01$.

‡ Correlation at $P = 0·001$.

TABLE 8. χ^2 ANALYSIS OF B1 AND (B2, B1/2, A-B1) PENDANTS FROM AUCKLAND

Parameter+	χ^2
Length (total)	0·004*
Width (maximum)	6·80 ‡
$w/t_{(max)}$	5·92 †
Perforation diameter	1·63 *

+ Yate's Correction applied in each case.

* Not significant.

† Significant at $P = 0·05$.

‡ Significant at $P = 0·01$.

(6) The Status of the *Kuru Papa*

Best (*op. cit.*) states *kura papa* are "flat" but nowhere describes them in detail. Does "flat" relate to frontal (plan) appearance, or to a rectangular or sub-rectangular cross-section? Since these pendants were probably described as "worn" the first alternative is more likely. Therefore, the greater the w/t ratio the greater the probability of a flat plan appearance. L'Horme's description (*op. cit.*) of this subtype mentions it as like a playing counter, suggesting that an upper length/width ratio limit existed. This value is not quoted by any authorities and the only basis to work on is the $l/w_{(max)} = 5{\cdot}0$ value derived from the 1769 observations of L'Horme *et. al.* (see Kelly 1967: plate 1). Thus *kuru papa*, if a separate subtype amongst the Auckland and Australian Museum samples, should show up as a distinct cluster within the area $w/t \geqslant 2{\cdot}5$ and $l/w \leqslant 5{\cdot}5$ when these two parameters are plotted against one another. As figures 29 and 30 show, there are undoubtedly a few pendants in either sample that must be classified as *kuru papa* on the basis of the above criteria, but no clustering is apparent and many marginal cases exist about the specified limits. All this suggests that the Australian and Auckland Museum "*kuru papa*" do not constitute a separate subtype but rather should be seen as terminal specimens, possessing small l/w ratios, within the continua subtypes of figure 3.

From L'Horme's description and associated graphical records (Kelly 1967: plate 1; Milligan 1958: plates 1 and 2) it would appear that the *kuru papa* existed as a late prehistoric straight *kuru* subtype, at least at Doubtless Bay. However, these pendants are neither common nor distinctive in (protohistorically-derived) collections, which must stem from their undesirability or unavailability as trade items. Because of their rarity the *kuru papa* cannot be considered a valid protohistoric-historic Classic Maori pendant subtype. Best's ascription of *type* status to it is probably based on Surville voyage documentation.

Why this prehistoric pendant subtype did not imitate other straight *kuru* in protohistoric trade response is not known, for it was presumably just as easily manufactured, and was present in an area where Maori-Pakeha trafficking was established early, at a time when the normative features of "desired" curiosities were not yet standardized. This, incidentally, raises the question of why pendants of A and A-B1 cross-sections did not supersede B1 and B2 specimens as preferred protohistoric trade items, since they would have been much easier and faster to manufacture. The answer must lie in the significance of Maori mental concepts of the desired shape of straight *kuru;* these were retained because straight *kuru* were not only trade items but were also utilized by the Maoris in the traditional manner. Only with the change to European equipment was there any significant production of A *kuru*, but "traditional" B pendants, likewise simple to manufacture, remained the favoured variety.

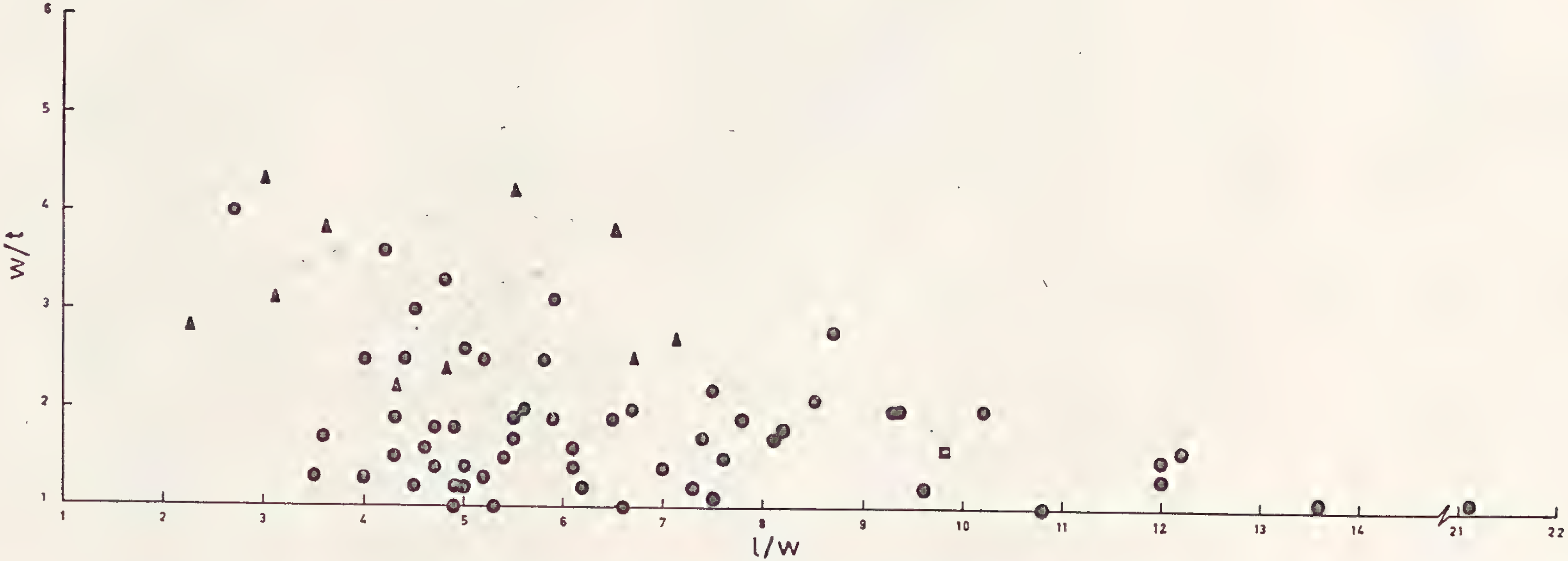


Fig. 29: Scatter diagram of w/t vs $1/w$ for Auckland Museum straight *Kuru*

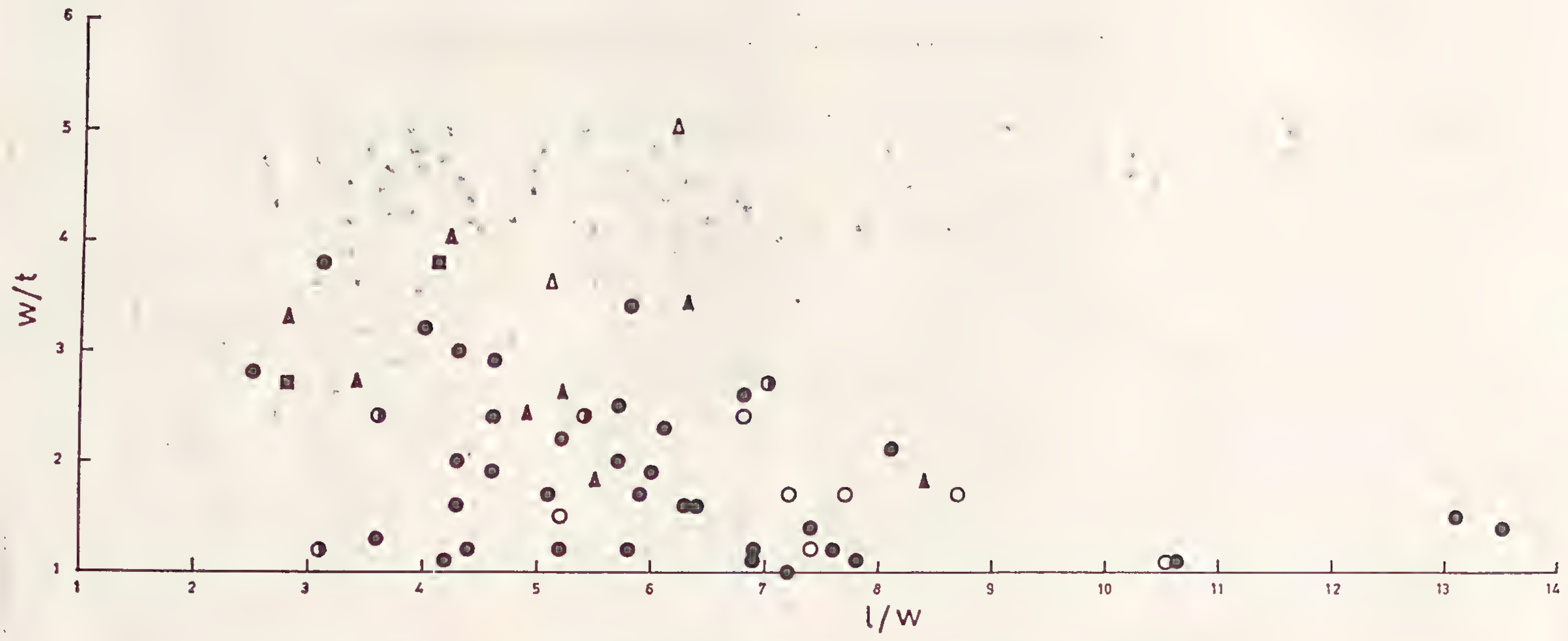


Fig. 30: Scatter diagram of w/t vs $1/w$ for Australian Museum straight *Kuru*

OTHER ELONGATED PENDANTS

Sixteen elongated pendants in the Australian Museum which do not conform to the straight *kuru* A and B subtype criteria are now considered. Five of these are *kuru kapeu* (also called *tautau*), and closely resemble straight *kuru* but for their characteristic curved distal ends (in hockey-stick fashion). The remaining pendants are anomalous.

(1) Descriptions of the Pendants

Metrical and other details of the five *kuru kapeu* are given in table 9. In the column entitled "Material" N is for nephrite or semi-nephrite and B bowenite.

Eleven *kuru* differing significantly from those of tables 1 and 9 above are listed in table 10, and a number of them illustrated in figure 31. Pendants E 54517 to E 54526 are from the Dixson Collection. Both E 1461 and E 2405 are characterized by pointed distal ends, in contrast to all the "M" pendants of table 1. The thickness changes, giving rise to varying cross-sectional ratios, are also a notable feature of these two *kuru*. Pendants E 2406 and H 334 are remarkable for their changing widths, thicknesses, and hence cross-sections, as shown in figure 31. E 54523 and E 54524, both fashioned in an attractive pale greenstone, are virtually identical in all respects, as is also the case for E 54525 and E 54526. However, all four pendants are markedly atypical in form as figure 31 shows. The final pendant shown is H 156 (cf. the photograph and line drawing in Thorpe 1924: 181), a beautiful "Cook Relic" specimen obtained from John Macrell. The Museum register lists this as an eardrop worn by a chief and presented by him to Captain Cook. Attached to a two-ply flax cord tied to the proximal end is a 65-cm length of thin twisted flax fibre (see figure 31, inset A).

(2) Discussion

The *kuru kapeu* is undoubtedly a prehistoric pendant type, as it was recorded in the East Coast-Hawkes Bay area in October 1769, when, in all probability, it was confined to male *rangatira* (Orchiston 1972b: Location 3 and 8 accounts). A tangiwai *kuru kapeu* with proximal end suspension grooving instead of a perforation has been reported (Rolston 1947: 260) from a Horowhenua swamp *pa*. On the basis of other artifact finds there (Rolston 1944) this pendant must be assigned a prehistoric date.

Genuine ("M") *kuru kapeu*, although present in museum collections, are not nearly as abundant as straight *kuru*, which suggests that during protohistoric times they did not react as vehemently to Maori-Pakeha trading activities. Possibly the reason for this is that straight *kuru* were much easier, hence less time-consuming, to manufacture. Nevertheless, production of this type may have continued during the protohistoric period as specimens have been reported from Oruarangi (Fisher 1941: 24–25, and plate 6), Pa Bay (Thacker 1961: 11), and Murdering Beach (Skinner 1915: figure 9), for example.

TABLE 9. AUSTRALIAN MUSEUM *KURU KAPEU*

Register Number	Length (l)		Perf. dia.	Width (w)		Thickness (t) at $w_{(max)}$	$w/t_{(max)}$	Material	Manufacture	Acquisition	
	Total	To perf.		At perf.	Max.					Method	Date
E 32709	63·0	4·5	1·7	7·0	11·9	4·3	2·8	N	M	E*	1929
E 54519	152·5	6·0	3·3	13·5	17·3	4·9	3·5	N	?E	D	1951
E 54520	145·5	6·4	2·2	10·2	17·5	6·9	2·5	B	?E	D	1951
E 54521	106·7	5·2	4·4	11·6	12·4	6·8	1·8	N	M	D	1951
E 54522	81·0	8·5	5·7	11·3	11·8	5·8	2·0	N	?E	D	1951

* From Auckland Museum.

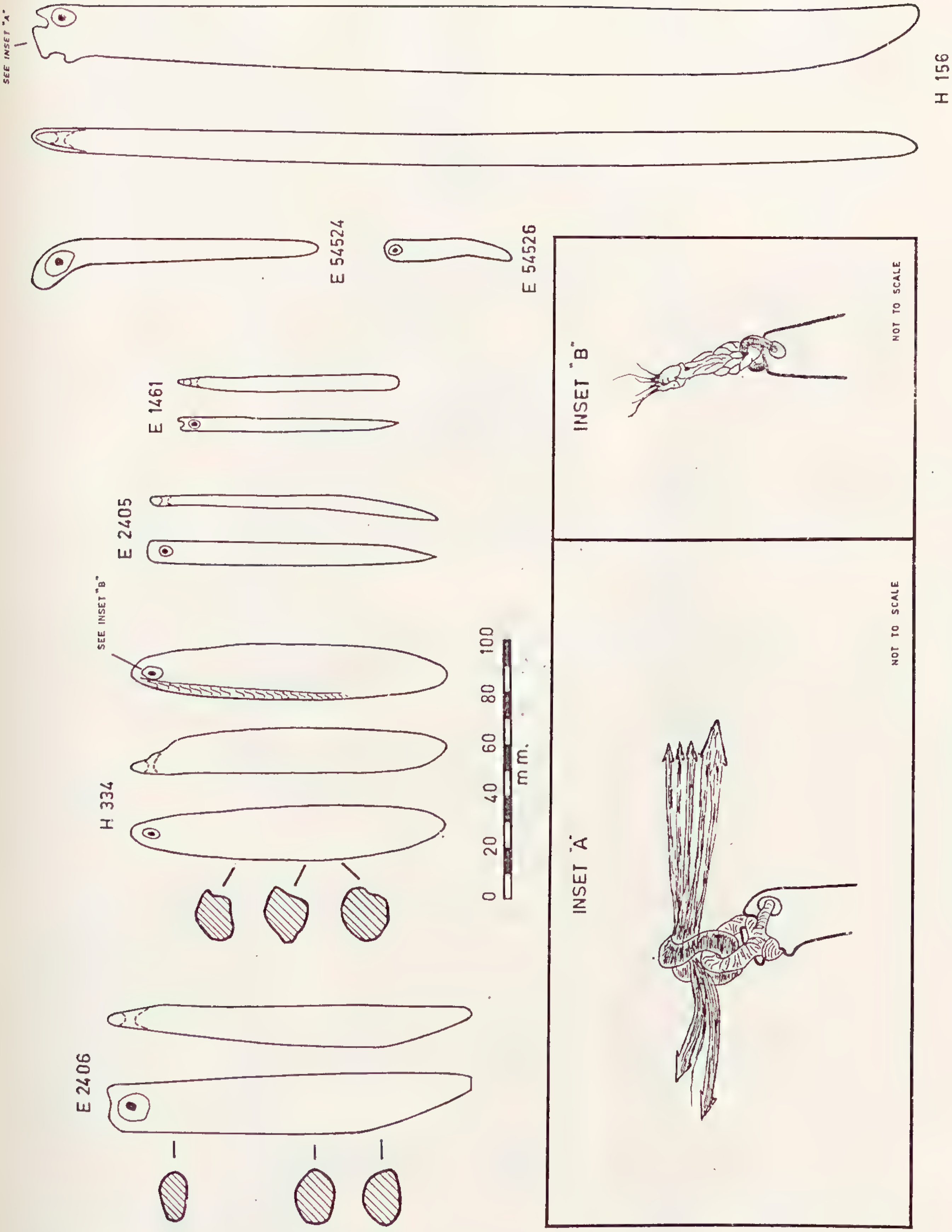


Fig. 31: Some examples of Australian Museum anomalous elongated *Kuru*

TABLE 10. AUSTRALIAN MUSEUM ANOMALOUS ELONGATED *KURU*

Register Number	Length	Cross-section	Material	Manufacture	Acquisition		Remarks
					Method	Date	
E 1461	>80·7	A	N	?E	P	1887	Broken at former perforation—see figure 31.
E 2405	105·8	A-B1	B	?E	P	1889	See figure 31.
E 2406	134·0	Irreg.	N	?E	P	1889	See figure 31.
E 52010	79·4	A	N	E	P	1946	R distal end. Variable thickness—very thin at proximal end. Identical width throughout entire length.
E 54517	155·3	A	N	E	D	1951	Atypical change in width. Identical thickness throughout entire length.
E 54523	107·4	B1 (var)	N	E	D	1951	Almost identical to E 54524.
E 54524	106·3	B1 (var)	N	E	D	1951	See figure 31.
E 54525	48·7	A-B1	B	E	D	1951	Almost identical to E 54526.
E 54526	46·0	A-B1	B	E	D	1951	See figure 31.
H 156	332·4	B1	B	M	D	1894	See figure 31.
H 334	117·3	Irreg.	N	M	D	1894	See figure 31.

One of the most notable features of table 10 is the prevalence of "E" and "?E" specimens. None of the shapes represented by these pendants, with the possible exceptions of E 2406 and H 334, is characteristically prehistoric or protohistoric. As tables 1 and 2 have shown, pendants of A cross-section are virtually non-existent in protohistorically-derived collections.

H 334 is one of the "Cook Relics" purchased by the Government of New South Wales from the Reverend Cannon Bennett. If an authentic Cook-era pendant, it in all probability came from Queen Charlotte Sound during either the second or third voyage.

H 156 is unique: although the author has visited all the major New Zealand museums in 1969, 1970, and 1971, and viewed large numbers of Maori pendants, nothing quite like it was seen anywhere. Contrary to Skinner's (1933: 6) claim, H 156 differs from his pendant No. 37 in that the latter has a curved distal end—almost in *kuru kapeu* fashion—and the suspension arrangement consists of one groove and a perforation. No Cook period locality attribution is possible for this pendant.

RARER PENDANTS

Considered in this section are nineteen pendants which differ radically from all the above specimens. Most of these can be allocated to well-defined types that are noted for their rarity (when contrasted with straight *kuru*).

(1) Descriptions of the Pendants

These pendants, mainly from the Dixson Collection, are listed in table 11. Pendants E 54464 to E 54453 are featured in plates 22–24, and the remainder illustrated in figure 32. E 54470 has tentatively been listed with the *pekapeka*, as this is where its closest affinities lie. Similarly, E 54463 is identified as a *hei matau* form. Pendants

TABLE 11. AUSTRALIAN MUSEUM RARER PENDANTS

Register Number	Type	Material	Manufacture	Acquisition		Remarks
				Method	Date	
E 54464	*Koropepe*	N	M	D	1951	
E 54465	*Koropepe*	N	M	D	1951	
E 54466	*Koropepe*	B	E	D	1951	
E 54548	*Koropepe*	B	E	D	1951	
E 54460	*Pekapeka*	N	M	D	1951	
E 54461	*Pekapeka*	B	?E	D	1951	
E 54462	*Pekapeka*	B	?E	D	1951	
E 54470	*Pekapeka* form	N	M	D	1951	Belonged to Nene's wife.
E 54467	*Poria*	N	M	D	1951	
E 54468	*Poria*	N	M	D	1951	
E 54463	*Hei matau* form	N	?E	D	1951	
E 54453	*Rei puta* form	N	M	D	1951	
E 484	Triangular pendant	N	M	P	1887	Lost by a chief of Pepin Island.
E 1459	Triangular pendant	N	M	P	1887	Parapara.
E 54469	Triangular pendant	N	M	D	1951	Belonged to Nene's wife.
E 54502	Triangular pendant	N	M	D	1951	
H 63	Triangular pendant	N	M	D	1895	
None	Triangular pendant	N	M	?	?	
E 489	Anomalous	N	M	P	1887	

E 484 to the unregistered specimen, all triangular to oval pieces of polished greenstone, constitute an as yet unnamed type here termed "triangular pendant". All the *koropepe*, *poria*, *pekapeka*, and triangular pendants have been bifacially worked, the reverse faces generally mirroring those illustrated. E 54460 and E 54470 are composed of the same source material: an attractive pale greenstone with yellowish streaks and blotches throughout.

(2) Discussion

Koropepe (snake-like amulets—see plate 22) were worn as ear ornaments (Best 1952: 229), and only made an appearance as greenstone artifacts in protohistoric or historic times (Orchiston 1972b). Indeed Skinner (1969) would go so

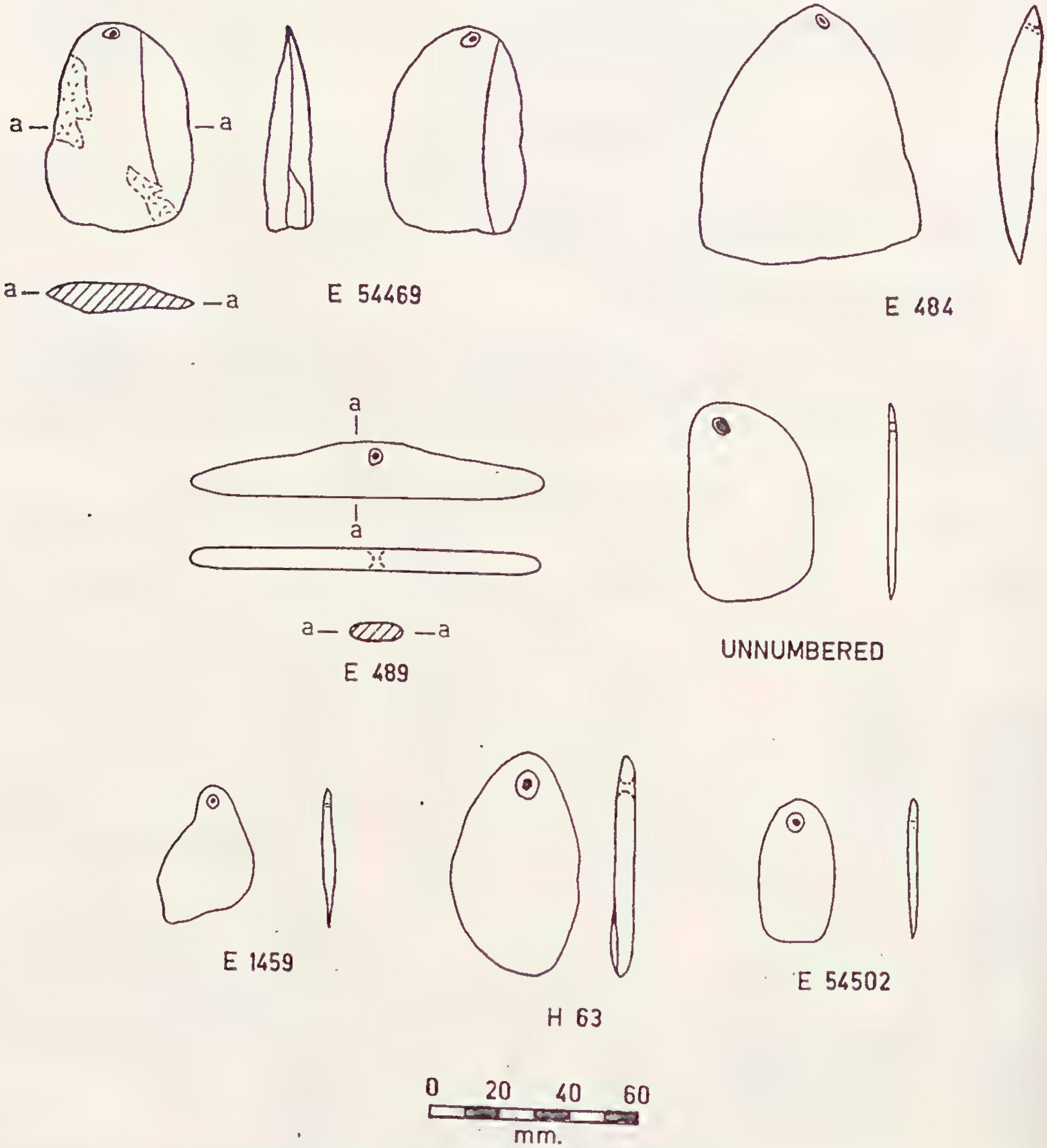


Fig. 32: Some examples of Australian Museum rarer pendants

far as to claim that all greenstone specimens were manufactured during the historic era, and that they were produced by Trevor Lloyd, of Auckland. The two "M" specimens in the Australian Museum thus demonstrate the degree of perfection fakers were able to achieve, also a feature of other faked rarer pendant types. E 54548, although manufactured with European implements, is interesting in that its eyes contain sealing wax, which was only introduced during the protohistoric period—by 1827 at the Bay of Islands (Wright 1950: 182).

Pekapeka (see plate 23), if present as a prehistoric type, were extremely rare, and only rose from obscurity in protohistoric times (Orchiston 1972b), their geographical distribution being restricted to the North Island with a strong Northland bias (Skinner 1935: 20). The three Sydney specimens closely resemble examples figured by Oldman (1935: Figure 20) and Skinner (1933: 8, No. 41 from Kaikohe). It is claimed in the Museum register that *pekapeka* form E 54470, together with E 54469 (a "triangular pendant"), was formerly the property of Nene's wife, and that these were taken from her remains. Tamati Waka Nene (an important protohistoric-historic periods chief from Hokianga—see Graham 1965: 36–37) had two wives and probably these pendants relate to Ihapera who died in 1837, rather than to Mata (Martha).

Poria, or parrot rings, were generally manufactured in bone, and greenstone examples (see plate 24) only made an appearance in protohistoric times (Orchiston 1972b). Once again the "M" classification of these ear pendants should be seen as indications of the artisans' skills.

No evidence is available on the prehistoric time-depth of the *hei matau* (fish-hook pendant), regarded by Buck (1962: 286) as either a neck or ear ornament depending on size. However, this type was certainly being produced at an early date in the protohistoric period (see Orchiston 1972b). These pendants are most abundant in South Canterbury, Otago, and Southland, although occasional North Island specimens do exist. E 54463, the Australian Museum example (see figure 24), differs somewhat from the *hei matau* figured by Hamilton (1908: 17–18, 20), Oldman (1935: 246, and figure 20), Skinner (1933: 315–316, plate B), and Webster (1948: 66–69), and viewed by the author in New Zealand museums, but morphologically it is more divorced from the Northland variety than those of other areas.

The *rei puta*, a whale-tooth neck pendant, was observed in Northland during the 1770's (see Orchiston 1972b), and turns up subsequently in protohistoric sites (e.g., Oruarangi—Fisher 1934: 276 and plate 62). But since it was always manufactured in whale ivory the Sydney specimen (plate 24) must be assigned a protohistoric or more likely historic date. Nevertheless, this artifact is a realistic copy and somewhat resembles the specimen from Orepuke figured by Hamilton (1908: the right-hand one on page 121; cf. Skinner 1943: 133, 142). Greenstone *rei puta* of the quality of the Sydney example are rare—a cursory examination of a number of New Zealand museum collections revealed only one similar specimen.

Triangular pendants, thin oval or triangular shaped pieces of polished greenstone (see figure 32), were observed as neck ornaments worn by *rangatira* at and near Hawkes Bay in October 1769 (Orchiston 1972b: location 6, 9, and 10 accounts). Their manufacture was continued during the protohistoric period, as evidenced by Murdering Beach specimens (Webster 1948: 72–73), for instance. H 63, another "Cook Relics" pendant, if authentic, probably came from Queen Charlotte Sound during the second or third voyage (Orchiston 1972a, 1972b).

E 1459 is attributed to Parapara where Heaphy (1848a, b, c) recorded a *pa,* "fishing station", and a small settlement, in 1848 (see figure 33). A field survey by the author in November 1969 showed the spit to be the only other location around the Inlet with archaeological sites, but since these belong to the Archaic Maori era there are some grounds for assigning this pendant to one of Heaphy's protohistoric sites. The origin of E 54469 has already been referred to above.

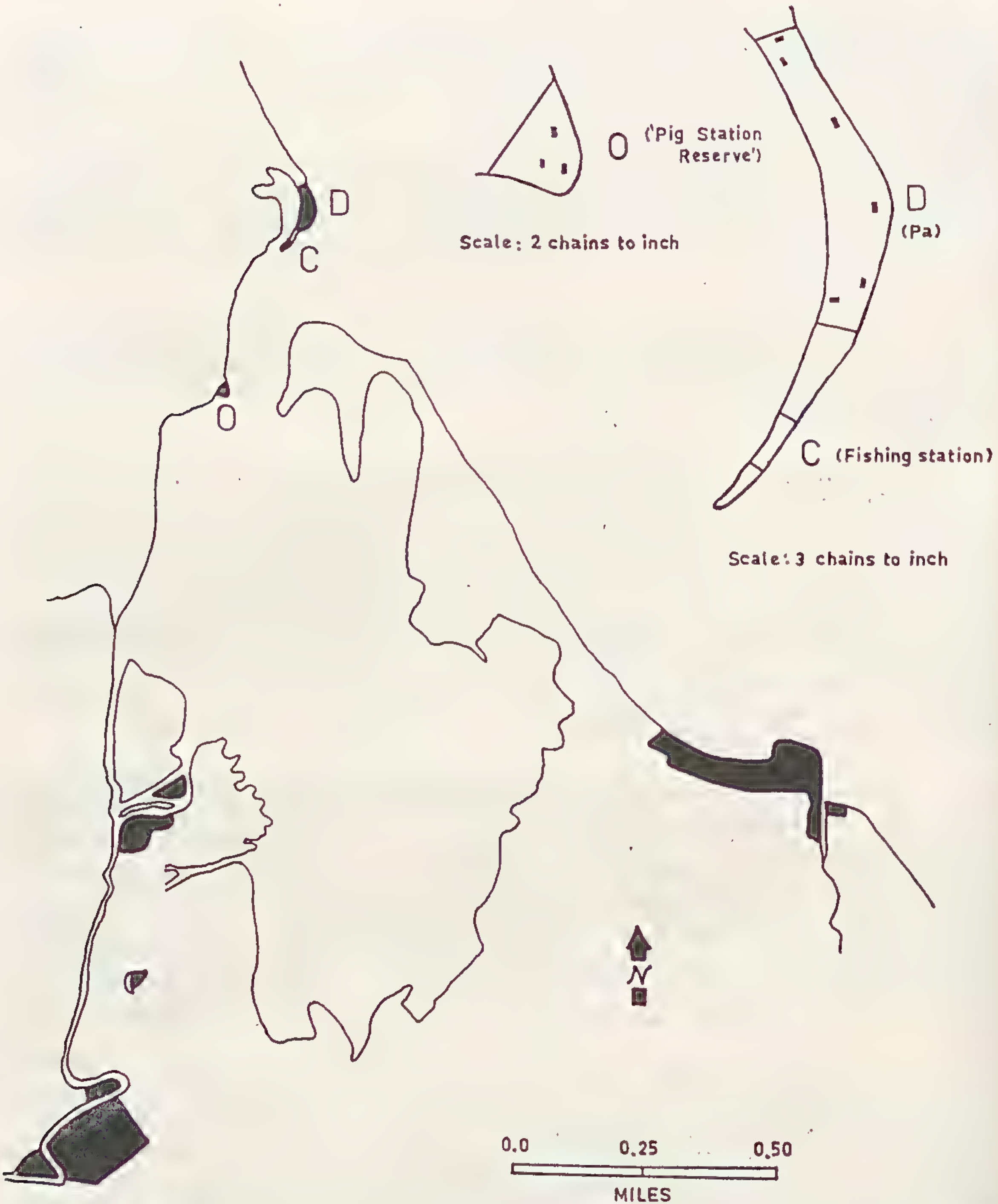


Fig. 33: Protohistoric Maori sites at Parapara (after Heaphy 1848a. Details of Reserves C, D, and O after Heaphy 1848b, and 1848c, respectively)

E 489 is an anomalous specimen that does not belong to any recognized type. It bears a superficial resemblance to a bone ear pendant figured by Parkinson (1784: f128, specimen No. 12) but nowhere mentioned in the text of any of the early protohistoric sources.

CONCLUSIONS

Greenstone pendants, as an important component of Maori material culture, generally feature prominently in museum displays. Types represented and on exhibition in the Australian Museum are the *tiki*, perforated chisel, triangular pendant, straight *kuru*, *kuru kapeu*, *poria*, *pekapeka*, *koropepe*, and *hei matau*.

The straight *kuru* is the most commonly represented greenstone type in the Australian Museum. Pendants of this form were not common in 1769–1770 but their number increased enormously during protohistoric times, primarily in response to European demands. It is to this period that most of the "M" straight *kuru* in the world's museums belong. These were mainly traded through North Island centres. The *kuru papa*, a flattened form of straight *kuru*, was present in 1769 at Doubtless Bay but did not continue as a subtype in protohistoric times. During early historic times there was a transfer to European implements in pendant manufacture, and with it came mass-production of straight *kuru* with A cross-sections, but B specimens were also easy to produce and, as "traditional" straight *kuru*, remained the preferred variety. Statistically, these latter "E" pendants differ little from their prehistoric-protohistoric "M" counterparts.

During late protohistoric times or in the historic period the wearing of straight *kuru* as neck pendants was introduced. Generally, these were metrically indistinguishable from those worn at the ear.

The recent trend towards quantitative studies of specific Maori artifacts (Crosby 1966; Hjarno 1967; Shawcross 1964a, b) has been continued in this paper. Metrical attributes of a random sample of 70 "M" straight *kuru* from the Auckland Institute and Museum have been investigated and relationships between various parameters explored. Technological and functional factors influenced or limited pendant length, width, and perforation diameter, all of which, when plotted in histogram form, show skewed unimodal Gaussian curves. Positive linear correlations were found between maximum width and *w/t*, and between perforation diameter and butt to perforation distance. There is no correlation between pendant length and maximum width. Australian Museum "M" straight *kuru* were subjected to identical examination and, on the basis of statistical analyses, and their scatter diagrams and frequency histograms, were found to differ significantly from the Auckland Museum random sample. Geographical and/or chronological factors are responsible for this sample bias.

Other pendant types considered in this paper are the *kuru kapeu* (5 examples), *hei matau* (1), *pekapeka* (4), triangular pendant (6), *koropepe* (4), *poria* (1), and *rei puta* (1). As greenstone types these last three only appeared during late protohistoric times or in the historic period. None of the other types listed was common, if at all present, in 1769–1770, and specimens currently in museums are predominantly protohistoric in origin. Faked specimens of all of these types were manufactured with European implements during historic times and it is to this category that all such Australian Museum pendants, except two *pekapeka*, some of the *kuru kapeu*, and most of the triangular pendants, must be allocated. The excellent workmanship put into some fakes is apparent in the cases of the *rei puta*, and two of the *koropepe*.

ACKNOWLEDGMENTS

The author is indebted to Dr R. Hall, of the Department of Psychology, University of Sydney, for assisting with the statistical analyses, and to Dr H. D. Skinner for helpful discussions and the loan of the MS of his book. The extensive assistance provided by Mr D. R. Simmons, Ethnologist at the Auckland Institute and Museum, and by Mr D. R. Moore, Dr J. P. White, and Mrs J. Smith, all of the Anthropology Department, Australian Museum, is gratefully acknowledged, and Mr C. V. Turner, of the Australian Museum, is thanked for taking the photographs. Finally, the author is grateful to the Trustees of the Australian Museum for permission to study the pendants, and to the Department of Lands and Survey for permission to publish figure 33.

REFERENCES

Archey, G., 1927. Notes on Maori artifacts. *J. Polynes. Soc.* 36: 72–75.

——— 1933. Wood carving in the North Auckland area. *Rec. Auckl. Inst. Mus.* 1: 209–218.

——— 1936. Maori carving patterns. *J. Polynes. Soc.* 45: 49–62.

Beck, Russell J., 1970. New Zealand jade: the story of greenstone, Reed, Wellington.

Best, E., 1912. The stone implements of the Maori. *Dom. Mus. Bull.* (4): 1–410.

——— 1924. The Maori. *Mem. Polynes. Soc.* 5 (2): i–ix, 1–637.

——— 1952. The Maori as he was. Government Printer, Wellington. (Third impression.)

Buck, P., 1962. The coming of the Maori. Whitcombe and Tombs, Wellington. (Second edition.)

Chapman, F. R., 1891. On the working of greenstone or nephrite by the Maoris. *Trans. N.Z. Inst.* 24: 479–539.

Conly, T., 1948. Greenstone in Otago in post-Maori times. *J. Polynes. Soc.* 57: 57–63.

Coutts, P. J. F., 1971. Greenstone: the prehistoric exploitation of bowenite from Anita Bay, Milford Sound. *J. Polynes. Soc.* 80: 42–71.

Crosby, E. B. V., 1966. Maori fishing gear. Unpublished M.A. Thesis, Department of Anthropology, University of Auckland.

Cumberland, K. B., 1950. A land despoiled: New Zealand about 1838. *N.Z. Geogr.* 6: 13–34.

Duff, R. S., 1949. An incised stone from Tāpawera, Nelson. *J. Polynes. Soc.* 58: 128–129.

Field, A. N., 1942. Nelson Province 1642–1842. Betts, Nelson.

Fisher, V. F., 1934. The material culture of Oruarangi, Matatoki, Thames. 1. Bone ornaments and implements. *Rec. Auckl. Inst. Mus.* 1 (5): 275–286.

——— 1941. The material culture of Oruarangi, Matatoki, Thames. 3. Stone implements and ornaments. *Rec. Auckl. Inst. Mus.* 2 (1): 15–27.

Golson, J., 1959. Culture change in prehistoric New Zealand. In J. D. Freeman and W. R. Geddes (eds), Anthropology in the South Seas, Avery, New Plymouth. pp. 29–74.

Graham, J. C. (ed.), 1965. Maori paintings. Pictures from the Partridge collection of paintings by Gottfried Lindauer. Reed, Wellington.

Hamilton, A., 1908. Fishing and sea-foods of the ancient Maori. *Dom. Mus. Bull.* (2): i–iv, 1–73.

Heaphy, C., 1846. Notes of an expedition to Kawatiri and Araura, on the western coast of the middle island. In N. M. Taylor (ed.), 1959, Early Travellers in New Zealand. Clarendon Press, Oxford. pp. 203–249.

——— 1848a. Original map entitled "plan No. 2" (SO 914) in Lands and Survey Office, Nelson.

——— 1848b. Original map (SO 916) in Lands and Survey Office, Nelson.

——— 1848c. Original map (SO 917) in Lands and Survey Office, Nelson.

——— 1862. A Visit to the Greenstone Country. *Chapman's New Zealand Monthly Magazine* 1: 107–111, 167–171.

Hjarno, J., 1967. Maori fish-hooks in southern New Zealand. *Rec. Otago Mus. Anthrop.* (3): 1–63.

Kelly, C., 1967. Maori and Solomon Islands drawings from the Surville expedition found in Spanish archives. *J. Polynes. Soc.* 76: 459–466.

L'Horme, P. De, 1769–1770. Extracts from the journal of Pottier De L'Horne (sic), lieutenant on the "Saint Jean Baptiste" for the Voyage of Discoveries in the South . . . In McNab 1914: 315–447.

McNab, R., 1914. Historical records of New Zealand. Government Printer, Wellington. (Volume 2.)
Meeson, J., 1889. The newly-opened cave near Sumner. *Trans. N.Z. Inst.* 22: 64–70.
Milligan, R. R. D., 1958. Ranganui, captive chief of Doubtless Bay, 1769. *J. Polynes. Soc.* 67: 180–203.
Monneron, M., 1769–1770. Extracts from the journal of a voyage made on the sailing vessel "Saint Jean Baptiste" (Captain Me. de Surville . . .) In McNab 1914: 231–295.

Oldman, W. O., 1935. Notes and illustrations. *J. Polynes. Soc.* 44: 244–248.
Orchiston, D. W., 1970. Preserved Maori heads in the Australian Museum, Sydney. *Dom. Mus. Rec. Ethnol.* 2 (3): 21–30.
——— 1971. Buller River artifacts in the Australian Museum, Sydney. *N.Z. Archaeological Assoc. Newsletter* 14 (4): 179–192.
——— 1972a. Cook voyage "trading stations". *Dom. Mus. Rec. Ethnol.*, in press.
——— 1972b. Maori neck and ear ornaments of the 1770's: A study in protohistoric ethnoarchaeology. *Jl. R. Soc. N.Z.*, 2: 91–107.

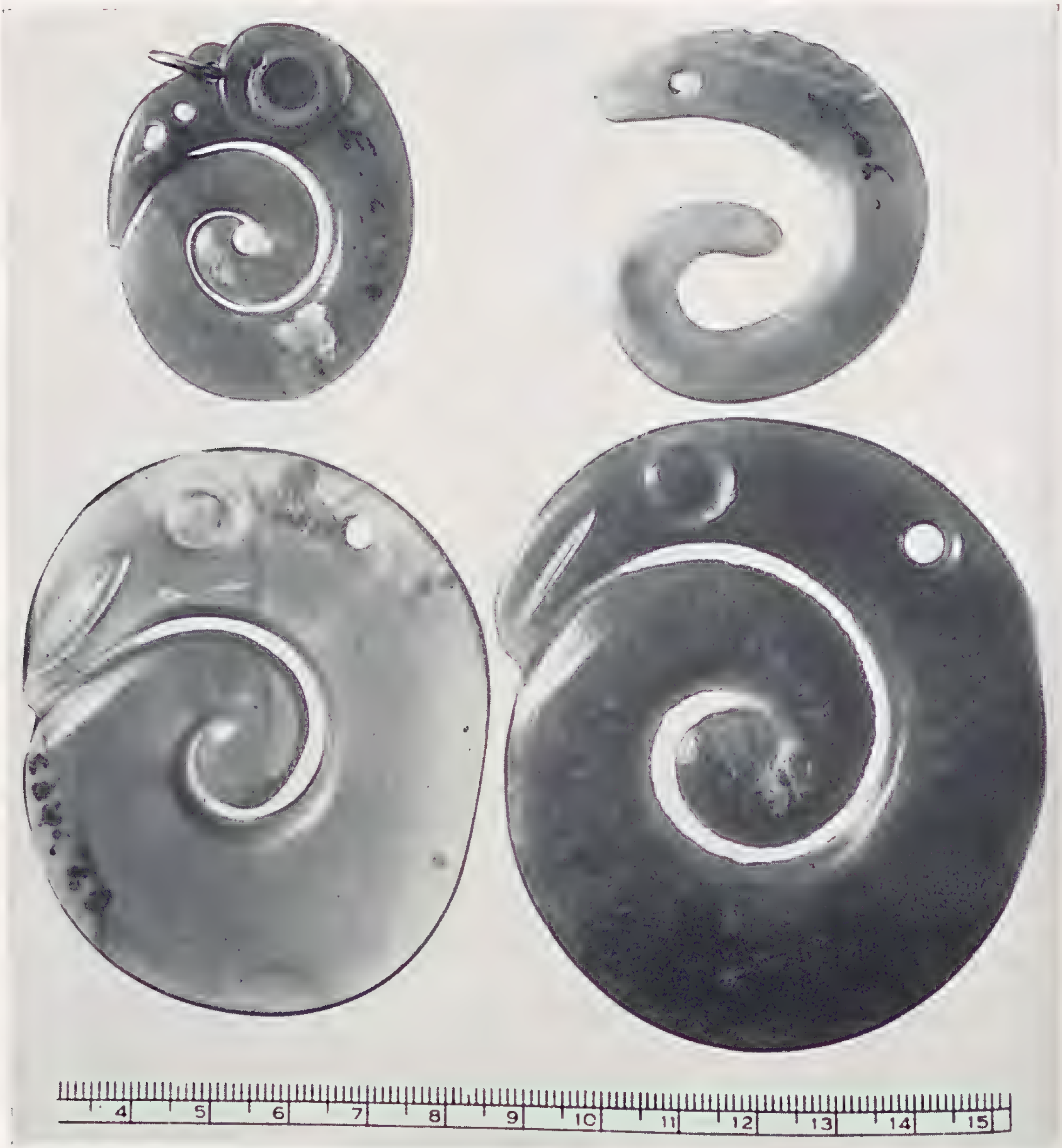
Parkinson, S., 1784. A journal of a voyage to the South Seas in His Majesty's ship the Endeavour . . . Dilly and Phillips, London. (Second edition.)
Peart, J. D., 1937. Old Tasman Bay. Lucas, Nelson.

Rolston, R., 1944. Excavations at *Pa*-site Lake Horowhenua. *J. Polynes. Soc.* 53: 163–174.
——— 1947. Further excavations at *Pa*-site Lake Horowhenua. *J. Polynes. Soc.* 56: 256–265.
Rouse, I., 1939. Prehistory in Haiti, a study in method. *Yale Univ. Publ. Anthrop.* (21): 1–202.

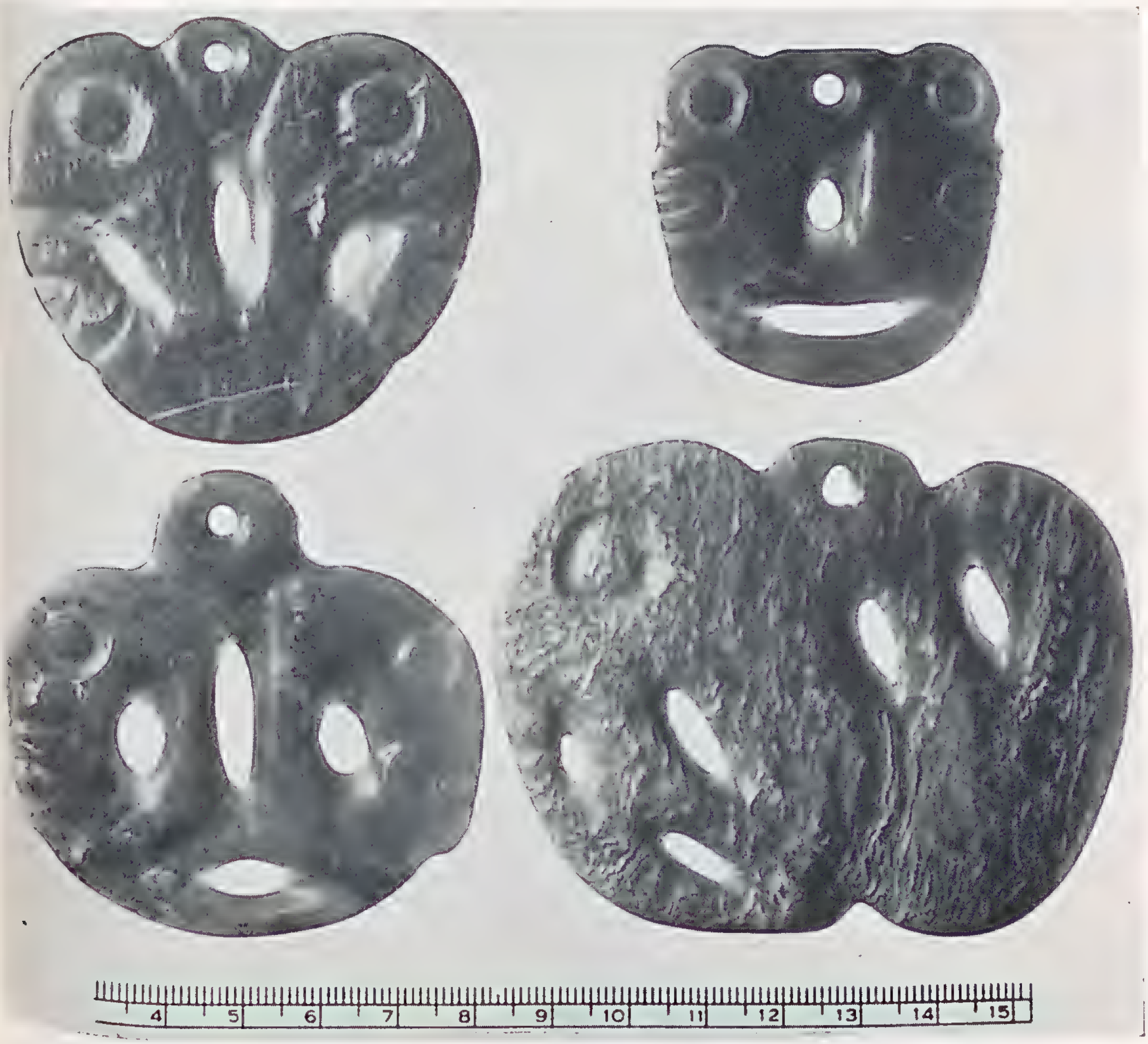
Shawcross, W., 1964a. Stone flake industries in New Zealand. *J. Polynes. Soc.* 73: 72–5.
——— 1964b. An archaeological assemblage of Maori combs. *J. Polynes. Soc.* 73: 382–398.
Skinner, H. D., 1915. Evolution of the Tautau, a Maori pendant. *Man*, 15: 2–5.
——— 1916. Evolution in Maori art. *Jl. R. Anthrop. Inst.* 46: 184–196, 309–321.
——— 1932. Maori amulets in stone, bone, and shell. *J. Polynes. Soc.* 41: 202–211, 302–309.
——— 1933. Maori amulets in stone, bone, and shell. *J. Polynes. Soc.* 42: 1–10, 191–203, 310–320.
——— 1935. Maori amulets in stone, bone, and shell. *J. Polynes. Soc.* 44: 17–25.
——— 1936. A Ngai Tahu carved skull box. *J. Polynes. Soc.* 45: 63–66.
——— 1943. Maori amulets in stone, bone, and shell. *J. Polynes. Soc.* 52: 132–152.
——— 1959. Murdering Beach collecting and excavating. The first phase: 1850–1950. *J. Polynes. Soc.* 68: 219–238.
——— 1969. Comparatively Speaking. Chapter on Maori amulets. In Ms.
Spring-Rice, W., 1962. Great Barrier Island. *N.Z. Archaeol. Assoc. Newsl.* 5: 92–95.
——— 1963. Harataonga—Gt. Barrier Island. *N.Z. Archaeol. Assoc. Newsl.* 6: 275–2.

Teviotdale, D., 1939. Excavation of Maori implements at Tarewai Point, Otago Heads. *J. Polynes. Soc.* 48: 108–115.
Thacker, M., 1961. Excavations at Pa Bay, Banks Peninsula. *N.Z. Archaeological Assoc. Newsletter* 4: 8–12.
Thorpe, W. W., 1924. Tangiwai ear-drop collected by Captain Cook. *N.Z. Jl. Sci. Technol.* 7: 181.
Trotter, M. M., 1967. Excavations at Katiki Point, North Otago. *Rec. Canterbury Mus* 8 (3): 231–245.
Tuckett, F. W., 1842. Cited in Rose, A. J., 1952. The Maori in northwest Nelson about 1840. *N.Z. Geogr.* 8: 63–69.
Turner, F. J., 1935. Geological investigation of the nephrites, serpentines, and related "greenstones" used by the Maoris of Otago and South Canterbury. *Trans. R. Soc. N.Z.* 65: 187–210.

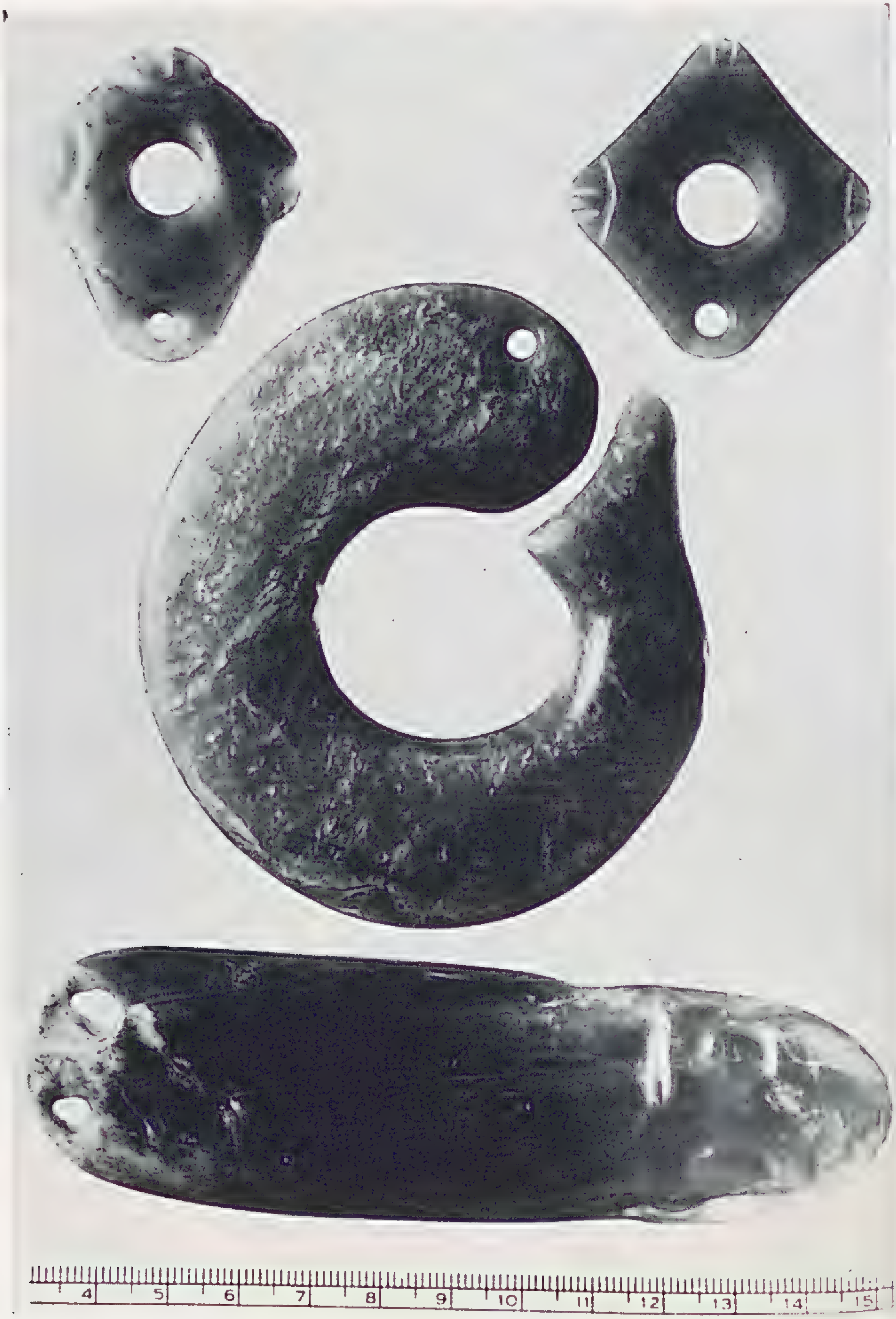
Webster, K. A., 1948. The Armytage collection of Maori jade. Cable Press, London.
Wright, O., 1950. New Zealand 1826–1827 from the French of Dumont D'Urville. Wingfield Press, Wellington.



Koropepe: upper left, E 54548; upper right, E 54466; lower left, E 54465; lower right, E 54464



Pekapeka: upper left, E 54460; upper right, E 54461; lower left, E 54462; lower right, E 54470



Poria: upper left, E 54467; upper right, E 54468. *Hei matau* form, centre, E 54463. *Rei puta* form, bottom, E 54453

EARTHWORMS (MEGASCOLECIDAE: OLIGOCHAETA) FROM MOUNT KOSCIUSKO, AUSTRALIA

NATIONAL MUSEUM
22 JAN 1973
OF VICTORIA

By

B.G.M. Jamieson

Zoology Department, University of Queensland

Figures 1–7 Manuscript received 16th August, 1971

SUMMARY

Earthworms collected for the Australian CSIRO from the Mt Kosciusko region of the Australian Alps are described and the zoogeography of the fauna is discussed. Of the known indigenous elements of the Australian Megascolecidae, Mt Kosciusko lacks Acanthodrilinae but harbours all tribes of the subfamily Megascolecinae, *viz.*, the tribes Perionychini, Dichogastrini and Megascolecini. The Perionychini are represented by *Diporochaeta pheretima* sp. nov., *Graliophilus montiskosciuskoi* sp. nov., *G. woodi* sp. nov., *Cryptodrilus fastigatus* Fletcher, 1889, *C. tenuis* Fletcher 1889, and by two species of the new genus *Vesiculodrilus*, namely *V. frenchi* (Spencer, 1892) and *V. purpureus* sp. nov. Other species, not from Mt Kosciusko, which are transferred to *Vesiculodrilus* as new combinations, are *Cryptodrilus gippslandicus* Spencer, 1892; *C. hobartensis* Spencer, 1895; *C. insularis* Spencer, 1895; *C. tanjilensis* Spencer, 1892; *Megascolides tisdalli* Spencer, 1900; *Plutellus uncinatus* Stephenson, 1933; *Cryptodrilus victoriae* Spencer, 1900, and *Megascolides volvens* Spencer, 1900. *Diporochaeta pheretima* sp. nov. is considered to have close affinities with *Vesiculodrilus* but must be placed in *Diporochaeta* pending revision of that genus. The Dichogastrini are represented on Mt Kosciusko by *Notoscolex montiskosciuskoi* sp. nov. and the Megascolecini by *Oreoscolex imparicystis* gen. et sp. nov. and *Megascolex celmisiae* sp. nov.

Evidence is presented for restriction of *Graliophilus montiskosciuskoi* to subalpine and alpine zones, a rare phenomenon in the Australian fauna. Zoogeographically the earthworm fauna of Mt Kosciusko has close affinities with surrounding southeastern Australia and its tertiary isolate, Tasmania.

INTRODUCTION

Mount Kosciusko includes the highest peak (7,316 feet) in Australia. It forms part of the Australian Alps, a southerly portion of the Great Dividing Range which extends from Cape York Peninsula to southeastern Australia and re-emerges in Tasmania. It is snow-capped in winter and has formerly been extensively glaciated. It holds particular interest, with other peaks in the Australian Alps, in supporting the only alpine herbfield on the Australian mainland and of thereby having the potentiality to harbour a cold-adapted endemic fauna.

Rec. Aust. Mus., **28**, page 215
38004-A

Although many species of earthworms have been described from New South Wales and Victoria, including parts of the Great Dividing Range (reference in Jamieson, 1971a), none has previously been described from Mt Kosciusko. The only taxonomic account of the Oligochaeta of Mt Kosciusko is that of Benham (1907) describing aquatic oligochaetes from the Blue Lake. All known native Australian earthworms belong to the family Megascolecidae.

In this paper earthworms from Mt Kosciusko collected for the Commonwealth Scientific and Industrial Research Organization by Dr T. G. Wood will be described and their zoogeography discussed. Because much of the material is in poor condition and many specimens were rejected as useless for taxonomic purposes, no attempt is made to estimate the relative abundance of each species in those localities in which it occurs. Some additional material from collections in the Australian Museum, Sydney, is also described. All specimens identified are clitellate or at least have well developed accessory genital markings.

Localities sampled in the CSIRO study are listed in Table 1, in which a numerical code to the localities is given. This code is used in the species-descriptions. Abbreviations for institutions in which collections have been lodged are: A.M. (Australian Museum); B.M. (British Museum); B.J. (author's collections); CSIRO (Department of Soils, Glen Osmond). Abbreviations for specimens are H (holotype); P (paratype) and A (additional specimens not designated types). Explanations of terminology used may be found in Michaelsen (1900) and (nephridia) in Jamieson (1971c).

SYSTEMATICS

Ten species, assignable to the subfamily Megascolecinae *sensu* Jamieson, 1971a, are present in the Mt Kosciusko collections. They are described in alphabetical order under their genera, which, in turn, are grouped according to the tribes to which they belong. A key to the ten species follows. For correct identification agreement with the illustrations cited is required.

KEY TO THE EARTHWORM SPECIES OF MT KOSCIUSKO

1. Nephridia two per segment throughout the body 2

— Nephridia more than two per segment throughout or in all except the caudal segments 6

2. (1) Nephridia with ectal bladders 3

— Nephridia lacking bladders 5

3. (2) Setae more than 8 per segment. Female pore unpaired .... *Diporochaeta pheretima*, p. 217. Fig. 2C

— Setae 8 per segment. Female pores one pair 4

4. (3) Midventral, postsetal, unpaired accessory genital markings in the region of segments VIII–XI .... *Vesiculodrilus purpureus*, p. 227. Fig. 2B

— Paired presetal accessory genital markings in line with the ventral setal couples in IX, X–XI .... *Vesiculodrilus frenchi*, p. 225. Fig. 2A

5. (2) Spermathecae 2 pairs .... *Graliophilus woodi*, p. 221. Fig. 1A, B

— Spermathecae 5 pairs .... *Graliophilus montiskosciuskoi*, p. 219. Fig. 4A

6. (1) Nephridia with ectal bladders 7
— Nephridia lacking bladders 8
7. (6) Prostate glands racemose (lobate), the duct branched externally to the gland .... *Cryptodrilus fastigatus*, p. 229. Fig. 3
— Prostate glands slenderly tubular, with externally unbranched duct .... *Cryptodrilus tenuis*, p. 233. Fig. 4B
8. (6) Setae 8 per segment 9
— Setae more than 8 per segment .... *Megascolex celmisiae*, p. 242. Fig. 5C
9. (8) Median nephridium on each side with a preseptal funnel in caudal segments. Spermathecae 4 pairs .... *Notoscolex montiskosciuskoi*, p. 236. Fig. 4C
— Caudal nephridia with numerous preseptal funnels in each segment. Spermathecae unpaired, in VIII and IX. . *Oreoscolex imparicystis*, p. 239. Fig. 5B.

Subfamily **MEGASCOLECINAE SENSU** Jamieson, 1971a

Tribe **PERIONYCHINI** Jamieson, 1971a

This is the only group of the Megascolecinae in which holonephridia are present. It was defined as purely holonephric, or with meronephridia in a varying number of segments anterior to holonephridia. Jamieson (1972c) has shown, however, that the genus *Cryptodrilus* has vesiculate meronephridia, a condition previously unknown, and that the genus has perionychin affinities. As there mentioned, erection of a new tribe, the Cryptodrilini, for *Cryptodrilus*, deserves consideration. In the present account *Cryptodrilus* is tentatively included in the Perionychini, as the nephridial vesicles and evidence of setal ratios previously demonstrated indicate close affinity. The definition of the Perionychini given in Jamieson (1971a) must therefore be augmented by the clause "If wholly meronephric, nephridia vesiculate".

Genus **Diporochaeta** Beddard, 1890

Diporochaeta pheretima sp. nov.

Fig. 2C; 6 I, J; 7 I

l = 20 mm, w (midclitellar) = 2.4 mm, s = 70 (apparently an old posterior regenerate). Form circular in cross section, moderately stout; secondary annulation absent. Pigmentless in alcohol excepting the yellowish clitellum. Prostomium broad, epilobous 1/2, open; canaliculi absent. Dorsal pores present but position of first indeterminable owing to damage. Setae perichaetine, commencing on II; 12l/12r in V, XII and XX; 14l/14r 10 segments from posterior end; setal lines mostly regular; the setal ring clearly interrupted in the ventral midline ($aa \doteqdot 2\,ab$) but no significant interruption occurring mid-dorsally ($zz \doteqdot yz$).

Nephropores small but readily seen, at the anterior margins of their segments in a single straight series on each side, first certainly visible in III (shortly behind intersegment 2/3); ventrolaterally situated, in line with the 6th seta from the ventrum in III–V, the 7th seta in VI as far as the caudal region; and the 8th seta in the latter region.

Clitellum strongly protuberant; sharply demarcated anteriorly and posteriorly; annular, embracing XIV–XVI; dorsal pores, intersegmental furrows, setae and nephropores retained, although the intersegments are not as distinct as elsewhere.

Male pores equatorial in *b* lines of XVIII, each on a circular moderately protuberant porophore which fills the segment longitudinally. Accessory genital markings a pair of small approximately circular presetal areas with pore-like centre, in each of segments VII, VIII and IX in *ab;* a midventral pit at the hind border of the clitellum, in 16/17, with tumid posterior margins extending to include setae *a;* a midventral transverse elliptical depressed area, in each of intersegmental furrows 17/18 and 18/19, extending lateral of *a* lines, each crossed by the furrow. Female pore unpaired, midventral on a slight prominence shortly presetal in XIV. Spermathecal pores not externally visible (see internal anatomy).

Some preprostatic septa thickened, none strongly. Last septal (pharyngeal) glands in IV but projecting over the oesophagus in V. Dorsal blood vessel single; last hearts in XII; supra-oesophageal vessel present (visible at least in XII); no subneural vessel detectable. Nephridia stomate, exonephric, vesiculate holonephridia throughout, the first nephridial body in II; the bladder a long, wide, convoluted tube changing little in form throughout the body.

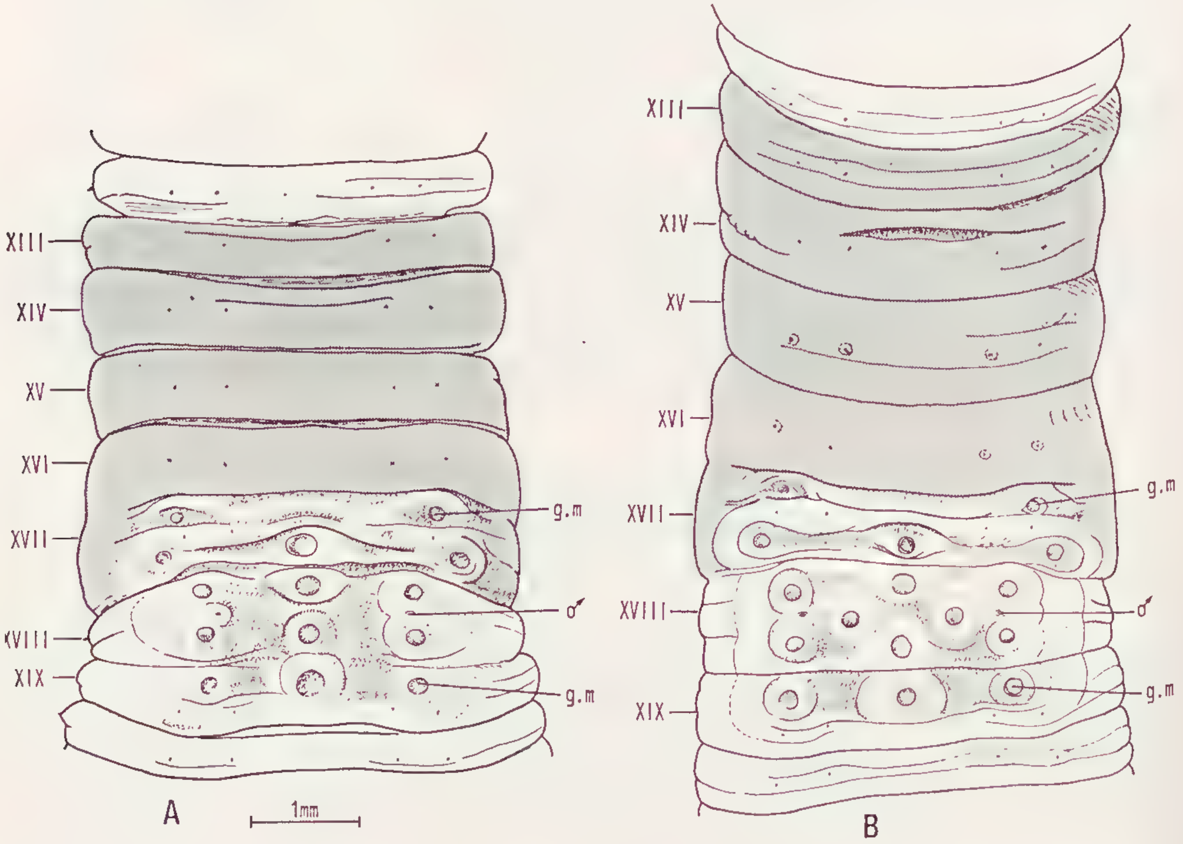


Figure 1.—Male genital fields of *Graliophilus woodi* sp. nov. A, holotype, 19/2. B, paratype 1, 19/6. By camera lucida. Clitellum shaded.

The following abbreviations are used in all the figures in this Record: ♀, female pore; g.m, accessory genital marking; ♂, male pore; ♂, po, male porophore; n.d, nephridial duct; n.ves, nephridial vesicle; np, nephropore; pr.d, duct of prostate; pr.g, glandular portion of prostate; sp. amp, spermathecal ampulla; sp.d, spermathecal duct; sp.div, spermathecal diverticulum; sp.p, spermathecal pore; v.d, vas deferens; v.n.c, ventral nerve cord. Numerals given after specimen or field-type identifications (e.g., 19/1) refer to localities of CSIRO samples.

Oesophagus in IV thin-walled but dilated; in V forming a small, readily compressible gizzard with muscular but not strongly thickened transparent walls. Oesophagus simple in VI-IX; widened and with circumferential vascular striae in X–XII; much dilated and with thick, deep, wavy longitudinal internal rugae in XIII and XIV; narrower but still rugose in XV; thin-walled and dilated but not internally rugose in XVI–XVII; intestine beginning anteriorly in XVIII, but the wide, well developed oesophageal valve evaginated into the cavity of the oesophagus in XVII; intestine not, however, widening and not thin-walled until anterior XXI; thereafter spiral; typhlosole and caeca absent.

Testes, copious sperm masses and large almost globular iridescent sperm funnels in X and XI; relatively very large racemose seminal vesicles in IX and XII, the posterior pair the larger. Ovaries large, laminar, consisting of several fused and separate egg chains, and large fleshy funnels in XIII; the oviducts entering the parietes separately; ovisacs absent. Prostates very thickly and indistinctly tubular; almost racemose in appearance, as the few coils of the gland are poorly demarcated; the gland in XVII–XIX; the duct of each fairly long and, excepting entally, with a muscular sheen. Penial setae 6 in the left bundle, each hair-like and flexible, with a few short stout spines scattered sparsely along the ectal extremity; greatest length (following the curvature) = 1.2 mm, greatest width (near base) ≑ 10 μ.

Spermathecae 5 pairs opening anteriorly in their segments in *b* lines, each with a slender, clavate to widely sacciform ampulla and a somewhat larger duct which receives a subspherical almost sessile inseminated uniloculate diverticulum laterally near its ental end; anterior spermathecae more slender than the posterior but length approximately the same; length right spermatheca of IX = 0.8 mm; ratio total length: length duct = 1.8; ratio total length: length diverticulum = 3.0.

Material examined: 12/3 Holotype (A.M., W. 4727).

Remarks: Diporochaeta pheretima, so named because of its striking external resemblance to species of the megascolecin genus *Pheretima*, including the unpaired intraclitellar female pore and trisegmental clitellum, shows clear affinities with some vesiculate species of *Diporochaeta* from neighbouring Victoria. Differences from them include the genital fields and it is the only species of *Diporochaeta* with a single female pore. The heterogeneity of the genus is discussed by Jamieson 1971c.

Resemblance of *D. pheretima* to species of *Perionyx* is also close, and includes the unpaired female pore, but in *Perionyx* the spermathecae lack diverticula.

Genus **Graliophilus** Jamieson, 1971e

Graliophilus montiskosciuskoi sp. nov.

Fig. 4A; 6A, C; 7A

l = 42 mm, w (midclitellar) = 4.5 mm, s = 77. Form moderately stout, circular in cross section excepting the male genital region. Pigmentless in alcohol. Prostomium tanylobous with very indistinct lateral margins, acute. Dorsal canalicula absent throughout the body. First dorsal pore 4/5. Setae in 8 regular longitudinal rows throughout, commencing on II.

INTERSETAL DISTANCES IN SEGMENT XII
IN *Graliophilus montiskosciuskoi*

	aa		ab		bc		cd	
	mm	st	mm	st	mm	st	mm	st
Holotype	1.19	11.22	0.32	2.97	1.79	16.83	1.05	9.90
interval/ab ..		3.78		1.00		5.67		3.33

	dd		dc		cb		ba	
	mm	st	mm	st	mm	st	mm	st
Holotype	3.33	31.35	0.98	9.24	1.65	15.51	0.32	2.97
interval/ab ..		10.56		3.11		5.22		1.00

Clitellum annular XIV–XVII, strongly tumid but narrower than the forebody; dorsal pores, intersegmental furrows and setae distinctly visible. Male pores minute on small medianly confluent papillae, each pore located median to *a* line and visible by virtue of an externally projecting penial seta; flanked laterally by a tumescence which extends almost to *c* line. Accessory genital markings present intersegmentally in 17/18–21/22, consisting of pairs of eye-like markings in *a* lines with tumid anterior and posterior lips which extend longitudinally to unite with those of adjacent segments and are confluent medianly so as to form transverse midventral tumid bands; the eye-like centres clearly visible in 19/20–21/22 not detected with complete certainty in 17/18 and 18/19 although tumid lips are present adjacent to these furrows; those in XVIII forming the already mentioned tumescences lateral to the male pores. Additional accessory genital markings present in segments IX to XII, each consisting of a very strongly protuberant unpaired midventral transverse pad which laterally extends almost to setae *b*, the anterior pad leaving the anterior third of segment IX free. Female pores inconspicuous in XIV, anteromedian to setae *a* at approximately 1/3 *aa*, both in a common transverse field. Spermathecal pores 5 pairs on inconspicuous papillae well median to *a* lines, in 4/5–8/9.

Septa 10/11 and 11/12 fairly strongly thickened; 12/13 and 13/14 moderately but decreasingly thickened; other septa slightly thickened or thin. Last septal glands anterior in IV.

Dorsal blood vessel single, continuous onto the pharynx; commissural vessels heart-like only in X–XII, in which they form 3 pairs of latero-oesophageal hearts, each of which receives a connective from the dorsal vessel and one from the supra-oesophageal vessel; the latter vessel slender, present in IX–XII. A pair of latero-oesophageal vessels extending from the pharynx to VIII median to the commissural vessels becomes suboesophageal by IX.

Gizzard very large and firmly muscular, almost cylindrical though widening slightly anteriorly; restricted to V but displacing posterior septa so that its posterior end lies approximately at the level of intersegment 9/10, oesophagus supressed by it until VIII in which it is well developed although slender. Oesophagus moderately expanded, moniliform and with circumferential vascular striae in IX to XIV; similar although narrower and apparently less vascularized in XV and XVI; intestine commencing gradually in XVII. No typhlosole detectable but maceration precludes certainty that it is absent.

Nephridia stomate holonephridia commencing in III; ducts avesiculate, penetrating the parieties in *c* lines; tufted nephridia absent.

Testes and iridescent seminal funnels free in X and XI; seminal vesicles racemose in IX and XII. Ovaries not recognizable; ovisacs absent.

Prostates a single pair, thickly tubular, describing several coils laterally from the ducts and restricted to XVIII; ducts sinuous and muscular, bulbous ectally; vasa deferentia of each side joining the prostate gland considerably ental of the duct. Penial setae present in XVIII; that on the right moderately stout, almost straight though slightly bowed entally; tapering to a fine point which is terminally, however, hollowed out and widened in the form of a spatula; ornamentation restricted to a few anteriorly directed spines on the curved side of the profile near the ectal end (only two spines distinguishable with certainty). Length = 575 μ; greatest width of shaft = 10 μ.

Spermathecae 5 uniform pairs, discharging anteriorly in segments V–IX, each with an elongate ovoid to sacciform ampulla and a short, poorly muscularized duct which bears a lateral digitiform, slightly clavate diverticulum near its junction with the ampulla; length of the left spermatheca of IX = 1.8 mm; ratio of total length : length duct = 3.3; ratio of total length : length diverticulum = 3.6.

Material examined: 9/1 Holotype (A.M., W. 4740).

Remarks: This species, which formerly would have been placed in *Plutellus*, is not congeneric with the type-species of the latter genus (see Jamieson, 1971d) but is placeable in *Graliophilus*, a genus erected by Jamieson (1972b) for Western Australian plutelloids. It is nearest to the *georgei*-species group but differs from all species currently referred to *Graliophilus* in having 5 pairs of spermathecae. The genital field distinguishes it from all other oligochaete species.

Graliophilus woodi sp. nov.

Fig. 1A, B; 6B; 7B

External morphology (Holotype and paratypes indicated):

l = 60–85 mm (mean of 5 = 77 mm), w (midclitellar) = 4–4.5 mm (mean of 5 = 4.2 mm), s = 147–151 (mean of 4 = 149). Form circular in cross section, blunt and very slightly clubbed at anterior and posterior ends, segments of the forebody at first simple, then biannulate but mostly triannulate; postclitellar segments weakly triannulate. Pigmentless in alcohol excepting the pale brown pigmented clitellum. Prostomium broadly tanylobous, parallel sided, bisected longitudinally by a moderately developed dorsal furrow which is not continuous onto the body (holotype and 5 paratypes). First dorsal pore 5/6, but probably not perforate until 6/7 (holotype and 4 paratypes), or doubtfully perforate at 6/7 but perforate at 7/8 (1 paratype). Setae in 8 regular longitudinal rows throughout, commencing on II; setae *a* and *b* absent in XVIII (holotype and 7 paratypes).

INTERSETAL DISTANCES IN SEGMENT XII

In *Graliophilus woodi*

Nephropores faintly visible in *c* lines near the anterior margins of their segments (holotype and 5 paratypes). Clitellum annular, well developed although not strongly protuberant, weaker on XIII than elsewhere; intersegmental furrows, setae and nephropores retained; dorsal pores obscured (holotype and 5 paratypes).

	aa		ab		bc		cd	
	mm	st	mm	st	mm	st	mm	st
Holotype	1.44	13.53	0.39	3.63	1.26	11.88	1.12	10.56
Paratype 1 ..	1.33	12.42	0.42	3.92	1.19	11.11	1.19	11.11
2 ..	1.40	11.87	0.53	4.45	1.37	11.57	1.33	11.28
3 ..	1.58	12.47	0.53	4.16	1.58	12.47	1.30	10.25
4 ..	1.44	12.81	0.53	4.69	1.30	11.56	1.12	10.00
5 ..	1.33	9.84	0.63	4.66	1.65	12.18	1.33	9.84
6 ..	1.44	13.02	0.39	3.49	1.40	12.70	1.09	9.84
7 ..	1.40	12.50	0.35	3.13	1.54	13.75	1.02	9.06
mean		12.31		4.02		12.15		10.24
interval/ab ..		3.06		1.00		3.02		2.55

	dd		dc		cb		ba	
	mm	st	mm	st	mm	st	mm	st
Holotype	3.54	33.33	1.12	10.56	1.26	11.88	0.49	4.62
Paratype 1 ..	3.79	35.29	1.09	10.13	1.30	12.09	0.42	3.92
2 ..	4.07	34.42	1.26	10.68	1.33	11.28	0.53	4.45
3 ..	4.25	33.52	1.33	10.53	1.58	12.47	0.53	4.16
4 ..	3.93	35.00	1.12	10.00	1.30	11.56	0.49	4.38
5 ..	5.12	37.82	1.19	8.81	1.65	12.18	0.63	4.66
6 ..	3.79	34.92	1.16	10.48	1.40	12.70	0.39	3.49
7 ..	4.00	35.63	1.02	9.06	1.54	13.75	0.35	3.13
mean		34.99		10.03		12.24		4.10
interval/ab ..		8.70		2.50		3.04		1.02

Male pores minute on XVIII, in *ab*. Circular pore-like accessory genital markings with tumid borders have a variable configuration, but in the holotype and 6 paratypes studied in detail the following arrangement was constant (illustrated): a pair anterior to, and a pair posterolateral to setae *b* of XVII; presetal and postsetal in *ab* of XVIII; presetal in *ab* of XIX; four midventral, unpaired markings present: postsetal in XVII, pre- and post-setal in XVIII and presetal in XIX. The greatest development of the field is seen in paratype 5 (locality 18); in addition to the constant arrangement this has a postsetal triplet in XVI and in XX; a presetal midventral marking in XVII, a unilateral (left) presetal marking in XVI and 2 additional, equatorial markings on each side in XVIII, one median to, the other lateral to, the male pores; in addition, the left-presetal and postsetal paired marking in XVII is replicated. None of the other 6 specimens has as full a development or shows any significant departure from this arrangement. A further paratype is, however, exceptional in lacking the paired presetal markings in XVII which are constant in the type-specimens described above. Female pore(s?); precise location indeterminable, situated in a transverse groove spanning *aa;* apparently single and midventral in paratype 1. Spermathecal pores minute, on 2 pairs of inconspicuous low papillae in 7/8 and 8/9 in *a* lines (holotype and 5 paratypes).

Internal anatomy (holotype, H, and paratypes P1 and 6).

Septa: 5/6 very delicate, attenuated by backward extension of the gizzard; 6/7 thin; 7/8 moderately thickened, 8/9–12/13 fairly strongly; 13/14–16/17 decreasing from moderately to slightly thickened; the remainder thin. Last septal glands filling III; perhaps extending slightly into IV.

Dorsal blood vessel single, continuous onto the pharynx. Dorsoventral commissural vessels in VII (or further anteriorly?) -XII; those in IX forming slender dorsoventral hearts; those in X–XII forming 3 pairs of moderately wide latero-oesophageal hearts, each arising from the dorsal vessel and receiving a slender connective from the supra-oesophageal vessel. Supra-oesophageal vessel occupying VII–XII (H); observed with certainty only in X–XII in the paratype. Subneural

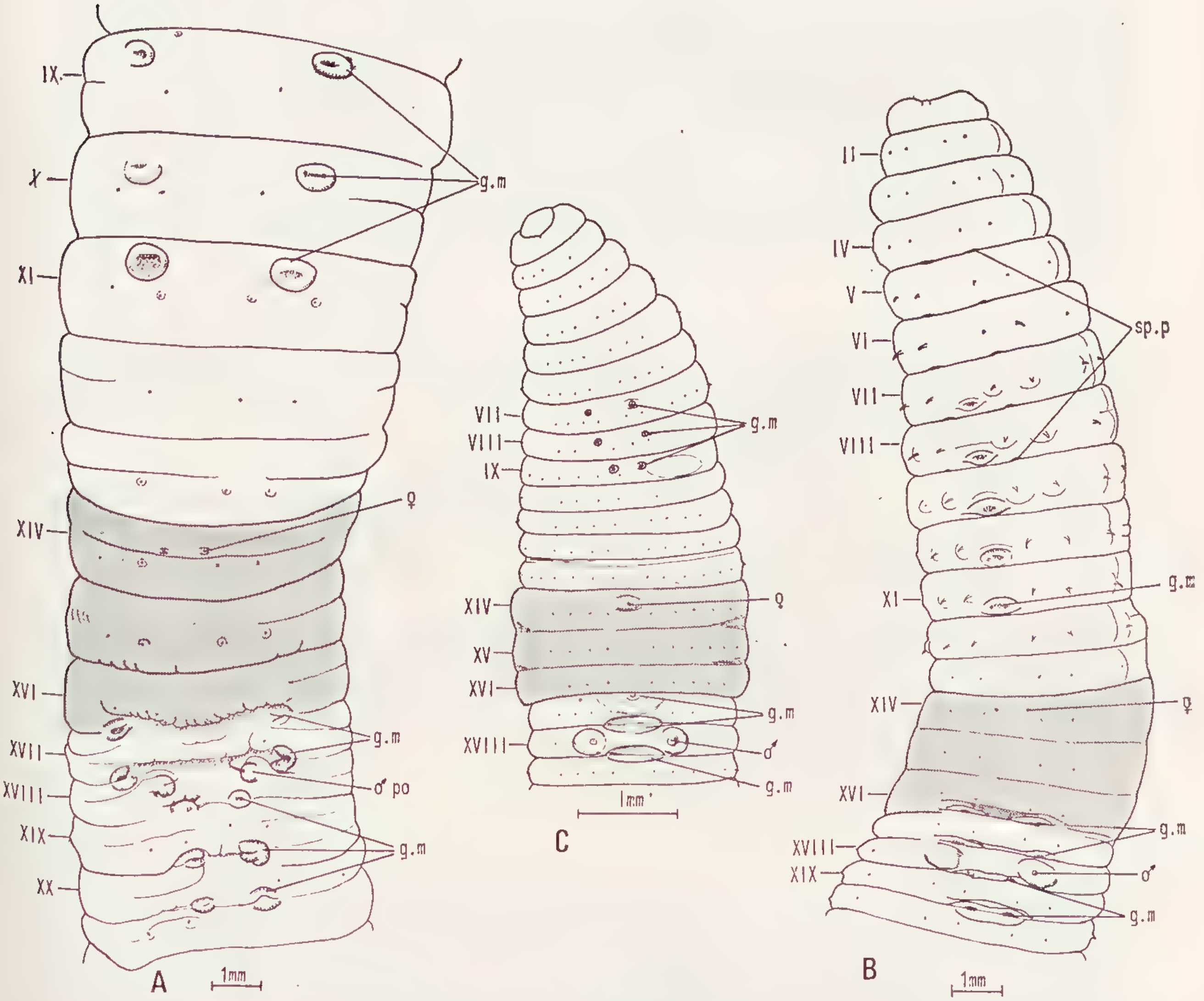


Figure 2.—Genital fields of: A, *Vesiculodrilus frenchi* (Spencer, 1892), specimen 1, 17/2. B, *Vesiculodrilus purpureus* sp. nov., holotype, 5/1. C, *Diporochaeta pheretima* sp. nov., holotype, 12/3. By camera lucida. Clitellum shaded.

vessel absent. Gizzard large and strongly muscular, in V, widening anteriorly to a rim-like expansion which is continuous with a thin walled crop-like proventriculus in IV. Oesophagus supressed in VI by backward extension of the gizzard; evidently vascularized and slightly moniliform in VIII–XVI; widest in XV and, especially, XVI but never conspicuously modified or enlarged; narrow in XVII and XVIII (H, P1). Vascularized part with internal rugae which are thinner and more laminar in XV and XVI (P6, holotype not sectioned). Intestine commencing at 1/2 XVIII, not greatly enlarged until XIX. A rather low narrow (laminar) convoluted dorsal typhlosole visible from XXI in the holotype or XIX in paratype 2.

Nephridia avesiculate simple holonephridia throughout; the post-septal bodies commencing in III; preseptal funnels demonstrated from XIV but presumably present further anteriorly; ducts entering the parietes in c lines throughout, with the exception (P1) that the ducts of those in III pass forwards to enter the parietes anteriorly in II above *d* lines.

Testes large iridescent sperm funnels and sperm masses free in X and XI. Seminal vesicles small, elongate-ovoid on the posterior wall of IX; elongate sacs curving dorsally around the gut on the anterior wall of XII; slightly lobulated. Ovaries (extensive laminae with many conjoined chains of large oocytes) and funnels in XIII; ovisacs absent in holotype but present, pendant posteriorly from septum 13/14, separate from the oviducal funnel, in paratype 1. Prostates compactly coiled, dorsoventrally depressed, tubular, restricted to XVIII; duct narrow, muscular and tortuous; each joined entally by the two vasa deferentia of its side.

Penial setae absent. Genital markings corresponding internally with large, rounded sessile glandular masses.

Spermathecae 2 pairs, discharging anteriorly in VIII and IX; each with an elongate-ovoid ampulla and slightly longer, poorly demarcated narrow duct which is joined entally by a clavate anteriorly directed diverticulum. Size uniform; length (right spermatheca of IX, holotype) = 3.7 mm; ratio total length: length duct = 1.8; ratio total length: length diverticulum = 5.1.

Material examined: 14 P9, A1; *17/1* P3, 4; *17/2* P5; *17/3* P6 (schizoparatype); *17/4* A1; *18* P7, 8 A3; *19/2* Holotype; *19/6* P1; *21* P2. (H, A.M., W. 4701; P1–5, A.M., W. 4696–4700; P7, 8, B.M.; P6, 9, A, B.J.; A, CSIRO).

Remarks: The genital field of this species distinguishes it from all other species assignable to *Plutellus* s. lat. The combination of other characters is also unique. Although it is placeable in the genus *Graliophilus* Jamieson, 1971e, it does not conform precisely with the difinitions of any of the species-groups, all from Western Australia, which have been recognized in that genus.

Genus **Vesiculodrilus** nov.

Setae 8 per segment. Combined pores of vasa deferentia and a pair of tubular prostates on XVIII. Gizzard in V; extramural calciferous glands absent although the oesophagus may be dilated and vascularized; typhlosole absent. Nephridia stomate, exonephric, holonephridia with large ectal bladders in a single longitudinal row on each side, in *c* lines; those in the first few segments sometimes tufted but retaining the bladder (and nephrostome?). Spermathecae 5 pairs, with single, uniloculate diverticula.

Distribution: Kosciuskan Division, Southern Faunal Province of Australia. Tasmania.

Type-Species: Cryptodrilus frenchi Spencer, 1892.

Other Species: Cryptodrilus gippslandicus Spencer, 1892; *C. hobartensis* Spencer, 1895; *C. insularis* Spencer, 1895; *Vesiculodrilus purpureus* sp. nov.; *C. tanjilensis* Spencer, 1892; *Megascolides tisdalli* Spencer, 1900; *Plutellus uncinatus* Stephenson, 1933; *Cryptodrilus victoriae* Spencer, 1900; *Megascolides volvens* Spencer, 1900.

Remarks: Definition of *Vesiculodrilus* is restricted above to a brief diagnosis as an account of the genus, with a revision of its species, is in preparation. These species were formerly assignable to *Plutellus* (see Jamieson, 1971c).

Australian genera resembling *Vesiculodrilus* in having nephridial bladders in a single straight line on each side are *Diporochaeta* (part.) Beddard, 1890 and *Fletcherodrilus* Michaelsen, 1891. *Diporochaeta* is distinguished in being perichaetine. The anatomy of the type-species, *D. intermedia* (Beddard, 1888), from New Zealand, with calciferous glands in X and XI and intestine commencing in XV, precludes placing the species here referred to *Vesiculodrilus* in *Diporochaeta*. Nevertheless, some vesiculate, Australian species of *Diporochaeta* s. lat. including *D. pheretima*, show close affinities with *Vesiculodrilus*. *Fletcherodrilus* differs from *Vesiculodrilus* in the very large ratio *dd: u* (approx. 0.5), midventral unpaired spermathecal and male pores and the remarkably dorsal location of the nephropores (in *d* lines).

Vesiculodrilus frenchi (Spencer, 1892)

Fig. 2A

Cryptodrilus frenchi Spencer, 1892: 135–136, Pl. XIV, fig. 10, 11, 12; Pl. XIX, fig. 66.

Megascolides frenchi; Beddard, 1895; 493.

Plutellus frenchi; Michaelsen, 1900: 175; Sweet, 1900: 116; Jamieson, 1971c: 87.

External morphology:

l = 122 mm; w (midclitellar) = 6 mm; s = 112 (specimen 4). Form circular in cross section throughout, moderately stout; segments after the first 2 or 3 biannulate; a faint dorsal canalicula present in the forebody. Peristomium bifid ventrally. Pigmentless buff in alcohol. Prostomium tanylobous, dorsal tongue narrow and parallel-sided and canaliculate; first dorsal pore 3/4 (imperforate); 4/5 perforate (Specimens 1–3). Setae in 8 longitudinal rows, commencing on II; all rows irregular at the caudal extremity; setae *a* and *b* replaced by penial setae in XVIII (4 specimens).

INTERSETAL DISTANCES IN SEGMENT XII

In *Vesiculodrilus frenchi*

	aa		ab		bc		cd	
	mm	st	mm	st	mm	st	mm	st
Specimen .. 1 ..	1.79	9.29	1.07	5.58	2.00	10.41	2.14	11.15
2	2.00	9.93	1.00	4.96	2.14	10.64	2.29	11.35
3	1.93	9.75	1.07	5.42	2.21	11.19	2.21	11.19
4	1.86	10.35	0.88	4.88	1.82	10.16	1.82	10.16
mean		9.83		5.21		10.60		10.96
interval/ab ..		1.89		1.00		2.03		2.10

	dd		dc		cb		ba	
	mm	st	mm	st	mm	st	mm	st
Specimen .. 1 ..	7.00	36.43	2.14	11.15	2.00	10.41	1.07	5.58
2	7.14	35.46	2.29	11.35	2.29	11.35	1.00	4.96
3	6.86	34.66	2.21	11.19	2.21	11.19	1.07	5.42
4	7.05	39.26	1.82	10.16	1.82	10.16	0.88	4.88
mean		36.45		10.96		10.78		5.21
interval/ab ...		7.00		2.10		2.07		1.00

Nephropores not externally visible. Clitellum annular, XIV–XVI; intersegmental furrows and setae retained; dorsal pores absent. Male pores equatorial in *ab* of XVIII, on fairly small but strongly protuberant papillae; a penial seta projecting from each pore. Five pairs of intersegmental genital markings present: in *b* lines in 16/17 and 17/18 and in *a* lines in 18/19, 19/20 and 20/21 (specimens 1–3). Three pairs of oval-oblong genital markings present a pair in each of segments IX–XI, presetally in *ab;* each marking with narrow raised margins; these markings present only in X and XI in specimens 2 and 3 and unilateral only, on the right, in 3. Female pores, on slight swellings, shortly anteromedian of setae *a* of XIV. Spermathecal pores minute, inconspicuous, 5 pairs in 4/5–7/8, at the anterior margins of their segments in *a* lines.

Internal anatomy (Specimen 4):

Septa: 4/5 thin; 5/6 slightly thickened; 6/7 moderately; 7/8–13/14 strongly thickened; 14/15 and 15/16 slightly thickened; the remainder thin. Last septal (pharyngeal) glands in IV. Dorsal blood vessel single, continuous onto the pharynx. Dorsoventral commissural vessels in V–XII; those in V–IX slender and dorsoventral only, each giving a lateral branch to the parietes before joining the ventral vessel; sufficiently enlarged in IX to be termed hearts; those in X–XII forming 3 pairs of large latero-oesophageal hearts, each arising from the dorsal vessel and receiving a connective from the supra-oesophageal vessel but not branched ventrally. Supra-oesophageal vessel in IX–XIII; very thin in XIII but elsewhere almost as wide as the dorsal vessel; distinct from the oesophagus. Latero-oesophageal vessel on each side of the gut observable in IV to IX, becoming sub-oesophageal in IX. Subneural vessel absent.

Oesophagus thin-walled and moderately wide in IV; gizzard large and strongly muscular though easily compressible, in V, widening to a rim like anterior expansion. Oesophagus slender and intersegmentally slightly constricted in VI–VIII; wider and evidently vascularized in IX–XV; much elongated and sinuous in XIV and XV; narrow, long and non-vascular in XVI; intestine commencing and about twice as wide as oesophagus in XVII; typhlosole absent. Nephridia stomate, vesiculate holonephridia throughout, postseptal bodies commencing in II; bladder elongate-ovoid narrowing ectally to a slender stalk (terminal duct) which enters the parietes presetally in *c* lines; the bladder receiving the slender nephridial tubule slightly subterminally. Nephridia of II and III appearing more coiled than elsewhere but not tufted and not notably enlarged. Testes, iridescent sperm funnels and sperm masses free in X and XI; seminal vesicles 3 pairs, on the posterior walls of IX and X and the anterior wall of XII, decreasing in size posteriorly; slightly lobulated; those in IX elongated dorsoventrally but sessile on the septum throughout their lengths. Ovaries consisting of a few chains of small oocytes in XIII; oviducal funnels not visible; ovisacs absent. Prostates one pair, tubular, compact and much wound, occupying XVII–XIX; the slender convoluted muscular duct restricted to XVIII. Penial setae (right seta of specimen 4) slightly bowed, tapering to a fine point, the ectal region of the shaft bearing a few anteriorly directed inconspicuous spines produced by notching of the margins, widely spaced lengthwise and not forming circlets; length = 1.6 mm, maximum width (near base) = 15 μ. Spermathecae 5 pairs, basically elongate ovoid with short, poorly demarcated duct which is joined entally by a small shortly clavate iridescent diverticulum; the right spermatheca of VII aberrant, having several small supernumerary pouches which are non iridescent and apparently ampullary.

Material examined: *17/1*, 1 (specimen 4) (CSIRO); *17/2*, 3 (specimens 1–3) (A.M., W. 4691–4693); *17/3*, 2 (B.J.).

Wider distribution: Croajingolong (East Gippsland) (Spencer, 1892).

Remarks: Agreement with the type description (Spencer, 1892) is close. Differences in Spencer's description from the Mt Kosciusko specimens are: the epilobous prostomium; spermathecal pores apparently in *ab;* restriction of accessory genital markings to X and XI; location of the posterior markings of XVIII in *ab* and extension of markings to 21/22, and restriction of seminal vesicles to IX and XII.

Vesiculodrilus purpureus sp. nov.

Fig. 2B; 6D; 7C, H.

External morphology (Holotype, H, and 2 paratypes, P1 and 2, unless otherwise stated):

l = 65 mm, w (midclitellar) = 4.5 mm, s = 111 (H). Form circular in cross section throughout with no conspicuous secondary annulation. Purplish brown pigmentation present dorsally. Dorsal canalicula present in the hindbody (H, P1). Prostomium narrowly epilobous 3/4 (P1). First dorsal pore 3/4 (H, P1). Setae in 8 regular longitudinal rows throughout, commencing on II; *a* and *b* absent in XVIII.

INTERSETAL DISTANCES IN SEGMENT XII

In *Vesiculodrilus purpureus*

	aa		ab		bc		cd	
	mm	st	mm	st	mm	st	mm	st
Holotype	1.23	11.29	0.74	6.77	1.37	12.58	1.09	10.00
Paratype 1 ..	1.07	10.34	0.57	5.52	1.29	12.41	1.07	10.34
Paratype 2 ..	1.02	9.29	0.67	6.09	1.33	12.18	1.37	12.50
mean		10.31		6.13		12.39		10.95
interval/ab ..		1.68		1.00		2.02		1.79

	dd		dc		cb		ba	
	mm	st	mm	st	mm	st	mm	st
Holotype	3.26	30.00	1.09	10.00	1.37	12.58	0.74	6.77
Paratype 1 ..	3.29	31.72	1.14	11.03	1.36	13.10	0.57	5.52
Paratype 2 ..	3.19	29.17	1.37	12.50	1.33	12.18	0.67	6.09
mean		30.30		11.18		12.62		6.13
interval/ab ..		4.94		1.82		2.06		1.00

Nephropores minute, faintly visible anteriorly in their segment in *c* lines, commencing on II. Clitellum annular, XIV–XVI, strongly tumid, intersegmental furrows fainter than elsewhere, dorsal pores suppressed at 14/15 and 15/16, setae clearly visible; faint glandularity of the posterior two thirds of XIII may be clitellar modification. A pair of combined male and prostatic pores equatorial in XVIII in *ab* on low papillae which fill *ab* and the length of the segment. Paired eye-like accessory genital markings present in 16/17 in *ab* nearer *a*, in 17/18 in mid *ab*, 18/19 slightly median to *a* and in 19/20 further medianly, the two markings in each furrow medianly contiguous, and those in 19/20 broadly united. Additional markings (H, P2) consisting of midventral, postsetal elliptical protuberances with depressed centres one in each of segments VII–XI (X and XI in paratype 1, anterior segments amputated). Female pores minute, anteromedian of setae *a* of XIV. Spermathecal pores 5 pairs of minute depressions in 4/5–8/9 in *a* lines.

Internal anatomy (Holotype; gross anatomy confirmed in the paratypes):

Septa 5/6 thin, 6/7 and 7/8 moderately thickened (7/8 the stronger); 8/9–13/14 strongly thickened, 12/13 the strongest; 13/14 and 14/15 slightly thickened, the remainder thin. Last septal glands in IV(?) but enveloping the gizzard in V.

Dorsal blood vessel single, traced to the brain. Dorsoventral commissural vessels in VI–XII; those in VI–IX slender and dorsoventral only; those in X–XII forming 3 pairs of large latero-oesophageal hearts, each receiving a connective from an indistinct supra-oesophageal vessel and from the dorsal vessel. Supra-oesophageal indistinct, only distinguishable from the oesophageal vascularization in X–XII. Nephridia stomate vesiculate exonephric holonephridia throughout (the single, preseptal funnels of the nephridia of III posteriorly recognizable in the segment anterior to the nephridial body; nephridia of II each with a neck to the anterior incomplete septum and funnel presumably present though not demonstrable).

Anterior bladders elongate-ovoid, becoming progressively more elongate an donce bent, the bend sometimes projecting medianly but no true diverticulum present; slender ectal duct of nephridium joining the apex of the bladder or very slightly subapical; bladders again shorter (elongate-ovoid) in caudal segments; tufted nephridia absent.

Gizzard in V though displacing septa to approximately 1/2 VIII, strongly muscular but slender and easily compressible. Oesophagus in VI–VIII moniliform, thin-walled and not evidently vascularized; in IX–XV more swollen, moniliform and with conspicuous circumferential vascular striae; slender and appearing non-vascularized in XVI. Intestine beginning abruptly, with well developed oesophageal valve, in XVII; typhlosole and muscular thickening absent. Testes, sperm masses and very large iridescent funnels free in X and XI; seminal vesicles in IX and XII, those in IX ovoid and undivided; those in XII elongate and transversely incised. Ovaries, large, tongue-like with many large oocytes, and funnels in XIII; ovisacs absent. Prostates thickly tubular, winding posteriorly from XVIII to XXII; each with a long sinuous muscular duct; vas deferens joining the gland well ental of the duct. Penial setae present (H, P1); the right seta of paratype 1 very slender, almost straight, drawn out to a delicate point, ornamented ectally with three widely spaced sets of two or three coarse spines. Length 1.44 mm, greatest width (near base) 10 μ.

Spermathecae 5 pairs, discharging anteriorly in their segments, each with a slender, clavate ampulla, a shorter duct and a bulbous narrow-stalked inseminated diverticulum joining the ental end of the duct; size uniform, length of the right spermatheca of VIII = 2.2 mm; ratio of total length: length duct = 4.2; ratio of total length: length diverticulum = 3.2.

Material examined: 5/1 Holotype (A.M., W. 4695); *5/9* Paratype *1* (B.J.); *13/2/B* Paratype 2(CSIRO).

Remarks: In having midventral, unpaired accessory genital markings in anterior segments, this species resembles *V.* (= *Cryptodrilus*) *victoriae* (Spencer, 1892), from which, however, it differs in the postsetal location of the markings and in the form of the penial setae (strongly hooked in a paralectotype of *victoriae*, Nat. Mus. Vict. G. 1410). It also closely resembles *V. frenchi* (Spencer, 1892), described above, but differs from that species in the unpaired condition of the anterior accessory genital markings and, their postsetal location. With the doubtful exception of *dd*, setal ratios in samples of *V. frenchi* and *V. purpureus* from Mt Kosciusko do not appear to differ significantly but the small number of specimens precludes rigorous demonstration of this.

Genus **Cryptodrilus** Fletcher, 1889

Cryptodrilus fastigatus Fletcher, 1889

Fig. 3

Cryptodrilus fastigatus; Fletcher, 1889a: 1541–1543.

Trinephrus fastigatus; Beddard, 1895: 483; Michaelsen, 1900: 185.

Cryptodrilus fastigatus; Jamieson, 1972b:161–166, fig. 5A, B; 6A, B; 7A.

Augmented diagnosis: Prostomium tanylobous. First dorsal pore 4/5. Setae in 8 regular longitudinal rows throughout; *aa: ab: bc: cd: dd: u* = 10.8: 7.2: 12.4: 16.6: 16.8:100 (mean of 5, Illawarra–Burrawang population); 14.1: 6.7:12.1: 15.8:16.7:100 (mean of 71, Mt Kosciusko population) (see p. 232). Nephropores in *a*, *c* and *d* lines in each segment, commencing anteriorly in II. Clitellum annular, XIV–XVII. A pair of combined male and prostatic pores, on small papillae, in the setal arc in XVIII, shortly lateral of *a* lines.

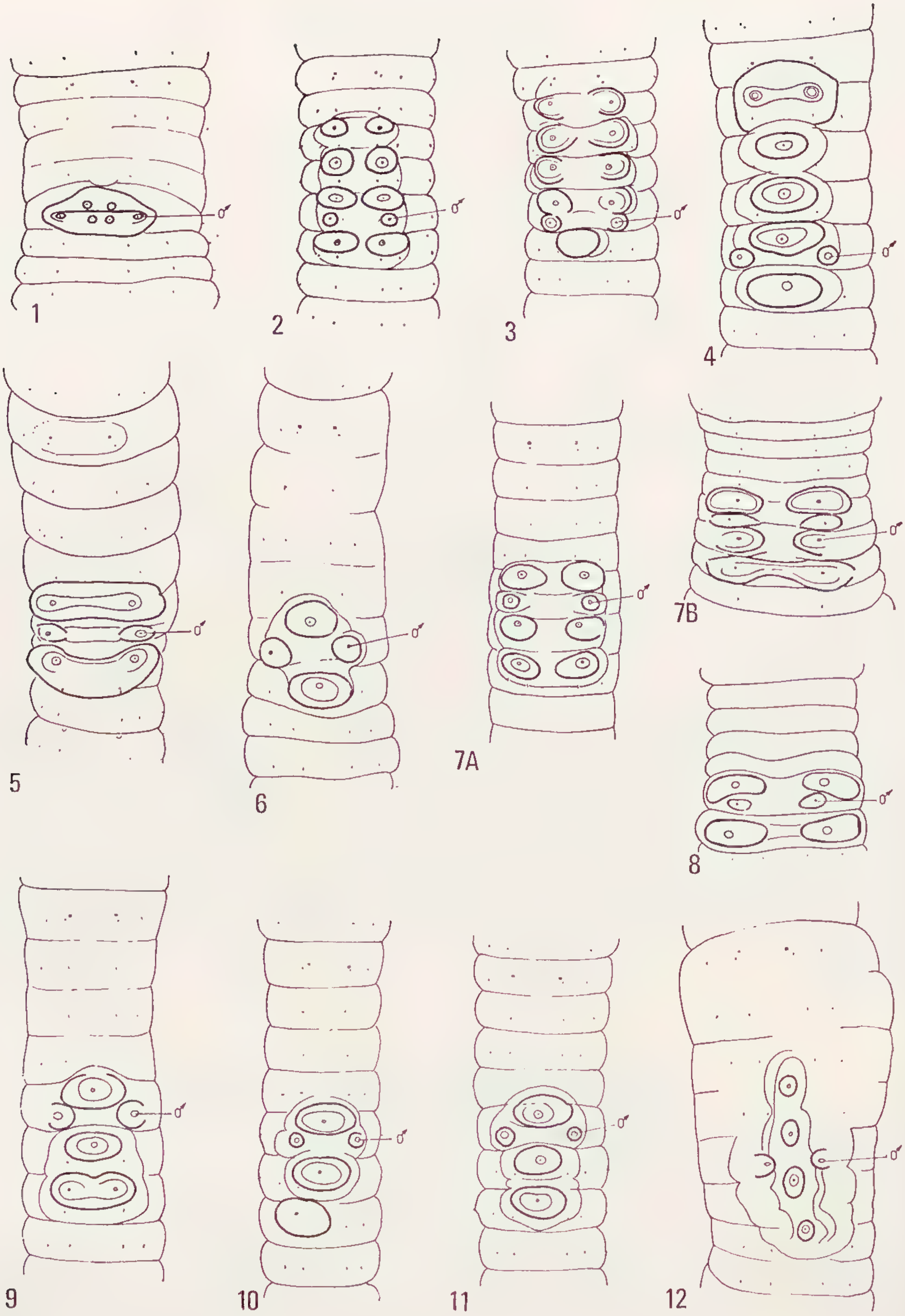


Figure 3.—Major variants of male genital fields in the Mt Kosciusko population of *Cryptodrilus fastigatus* Fletcher, 1889. Field: 1, Typical field, 18. 2, Kiandra Track. 3, Rawson's Pass (Aust. Mus. W. 2654). 4, Kiandra Track. 5, Rawson's Pass (Aust. Mus. W. 2654). 6, Mt Kosciusko Road (Aust. Mus. W. 2662). 7A, same locality. 7B, 17/2. 8, 17/4. 9, Mt Kosciusko Road (Aust. Mus. W. 2662). 10, same locality. 11, same locality. 12, 13/2/B.

Genital field consisting typically of an approximately elliptical tumescence surrounding the male pores, reaching from the anterior region of XVIII to the anterior margin of XIX, and traversed by a deep narrow depression which includes the male papillae at its lateral limits and carries a pair of accessory genital markings (small rounded papillae, each with a pore-like centre) on its anterior wall and a further pair on its posterior wall well median of *a* lines (Fig. 3, 1). Extreme variations in the field occur (Fig. 3, 2–12), of which the chief are as follows (in all variants the male porophores maintain their location lateral to *a* lines but the surrounding tumescence and typically located accessory markings are absent): (Fig. 3, 2) 4 pairs of accessory presetal genital markings, in XVI, XVII, XVIII and XIX; (3) 4 pairs of presetal genital markings, in XV–XVIII with a midventral unpaired marking in XIX; (4) paired but medianly united presetal markings in XV and midventral unpaired markings in XVI, XVII, XVIII and XIX; (5) paired but medianly united presetal markings in XVIII and XIX; (6) midventral unpaired markings in XVIII and XIX; (7) 3 pairs of presetal markings, in XVIII, XIX and XX; (8) presetal paired markings in XVIII and XIX only (type 8 is the commonest condition on Mt Kosciusko, occurring in more than 50 per cent of all specimens); (9) midventral, unpaired presetal markings in XVIII and XIX, paired but medianly united presetal markings in XX; (10) as (9) but the marking in XX unilateral; (11) midventral, unpaired presetal markings in XVIII, XIX and XX; (12) midventral, unpaired, intersegmental markings in 16/17, 17/18, 18/19 and 19/20. Female pores shortly anteromedian of setae *a* of XIV. Spermathecal pores at the anterior margins of VIII and IX, in *a* lines.

Dorsal blood vessel single; last hearts in XII. Gizzard rudimentary in V; oesophagus strongly dilated in XIV–XVI. Intestine commencing in XVIII; typhlosole absent. Nephridia 6 per segment, each with an elongate to subspherical bladder; the median (*a*) nephridium on each side in the mid and hind body with a preseptal funnel and caudally enlarged. Testes and funnels free in X and XI; seminal vesicles in XI and XII. Prostates large and racemose, each with an anterior and posterior portion; the duct branching and with 2 main rami external to the glandular portions. Penial setae absent. Ovaries and funnels in XIII; ovisacs absent. Spermathecae each with 2 subspherical diverticula near the ental end of the duct, which is almost 0.6 of the total spermathecal length.

Remarks:

The Mt Kosciusko material of *C. fastigatus* reveals a variability in the configuration of the male genital field which is unparalleled intraspecifically elsewhere in the known Oligochaeta. That the variability is intraspecific rather than supraspecific is indicated by the following evidence:

(1) Specimens with all field types have the same internal anatomy.

(2) The different field types (Fig. 3) can be interrelated in ways which suggest that they are the expression of relatively small genetic variations of a basic genotype or represent individual variations (also perhaps genetically determined) in a not highly canalized morphogenesis (ontogeny).

(3) In other Megascolecidae it has been shown that setal ratio parameters differ between different intraspecific populations (e.g., Jamieson and Bradbury, 1972, for *Didymogaster sylvaticus*). Setal ratios in *C. fastigatus* are summarized below.

INTERSETAL DISTANCES IN SEGMENT XII

In *Cryptodrilus fastigatus*

Locality	aa		ab		bc		cd		dd		No.
	mean	S.D.*	mean	S.D.*	mean	S.D.*	mean	S.D.*	mean	S.D.*	
Kosciusko 2	12.0	..	7.0	..	12.0	..	17.0	..	16.0	..	1
5	13.4	1.2	6.1	0.8	12.6	1.1	16.3	1.1	16.6	1.6	9
8	14.0	..	6.0	..	14.0	..	16.0	..	14.0	..	1
9	14.5	..	7.0	..	12.0	..	15.5	..	16.5	..	2
12	13.5	0.5	6.3	0.5	12.8	0.4	16.2	0.7	15.8	1.6	6
13	13.6	1.4	6.9	0.6	12.1	0.7	16.1	0.7	16.2	1.9	9
17	14.8	1.2	6.7	0.6	11.8	0.6	15.5	0.9	17.0	1.9	26
18	14.0	1.2	7.0	0.5	11.9	1.2	15.7	0.5	16.9	2.9	9
22	15.0	..	6.0	..	12.0	..	16.0	..	17.0	..	1
23	14.5	..	7.0	..	11.5	..	15.0	..	18.5	..	2
25	15.0	..	6.5	..	12.0	..	14.5	..	17.0	..	2
Total	14.1	1.3	6.7	0.6	12.1	0.9	15.8	0.9	16.7	2.0	68
Illawarra–Burrawang	10.8	0.7	7.2	0.4	12.4	0.5	16.6	0.5	16.8	0.7	5
Rawson Pass	14.3	..	7.0	..	11.7	..	15.7	..	17.0	..	3

* S.D. — Standard deviation.

The five major groups, representing localities 5, 12, 13, 17 and 18, are not significantly different one from the other or from the total CSIRO collection as judged by the means and standard deviations of their setal ratios. Groups 5 and 17 consist of 89 per cent and 85 per cent field-8 specimens, respectively, and indicate that at least field-8 worms from Mt Kosciusko have setal ratios which form one population. The other groups (12, 13 and 18) contain a mixture of fields (50% field-10/0% field-8/33% field-8/mixture; 44% field-8/44% typical field, respectively) but their ratios form one population with groups 5 and 17, indicating that field types are not correlated with setal ratios. Furthermore, a subsample consisting of five specimens with typical fields was not significantly different from the total CSIRO sample (nor from any single locality with a sufficiently large sample) at the 2 per cent level of significance by a Wilcoxon two-sample test (two-tailed). In addition, a sample from Rawson's Pass, Mt Kosciusko, collected independently in 1929 with a number of variants of field-3, was shown to possess ratios from the same population as the CSIRO specimens. The fact that the specimens from Mt Kosciusko have only one population of setal ratios and that there is no correlation with field-types support the conclusion, above, that the great variation in the genital field is intraspecific.

It should be noted that conspecificity on Mt Kosciusko of possessors of the typical field (field-1) with those with other genital fields has been demonstrated primarily from consideration of setal ratios as the typical field does not show as convincing an intergradation with other fields as do the latter with each other. On the other hand, conspecificity of the total Mt Kosciusko sample with the Illawarra type-specimens of *C. fastigatus* rests on the exact conformity of field-1 on Mt Kosciusko with that of the type-specimens as the setal ratios of the latter show relatively poor agreement with Mt Kosciusko material. Thus, in the Wilcoxon Test, *aa* in the type-specimens (combined with Burrawang specimens which have similar ratios) is different at the 1 per cent level of significance from the total CSIRO Kosciusko sample and at the 5 per cent level from Kosciusko specimens with the typical field.

(4) The distribution curve for individual intersetal distances (e.g. *aa*) for all specimens measured is unimodal and approximately symmetrical, approximating a normal curve. Bi- or polymodality would be expected if the samples represented a mixture of populations.

Material examined:

CSIRO material: *2/2* 2; *5/1* 3; *5/5* 5 (1 B.M.); *5/7* 1; *5/8* 3 (CSIRO); *8/1* 1; *9/1* 7 (1 B.J.); *10/1* 1; *11/1* 1; *12/2* 5; *12/4* 2; *12/8* 1; *13/1* 1 (B.M.); *13/2* 1; *13/2/A* 1; *13/2/B* 2 (1 B.J.); *13/3* 10; *14/1* 5; *17/1* 3; *17/2* 13; *17/3* 4 (2 B.M.); *17/4* 4; *17/5* 9 (1 CSIRO); *17/6* 3 (1 B.J.; 1 CSIRO); *18* 9 (1 B.M.; 1 B.J.; 1 CSIRO); *21/1* 2; *22/1* 1; *23/1* 3 (1 B.M.); *25* 2. All specimens in the Australian Museum (W. 4582–4661) except where indicated. Other material: 14 specimens, 2 mile post (near) Mt Kosciusko Rd, (below Etheridge Ridge) 6,600 ft, 11.I.1929, W. Boardman, A.M. W. 2662. 11 specimens, bank of small stream which crosses Kiandra track near Mt Kosciusko, N.S.W. 7.I.1929, W. Boardman, A.M. W. 2663 13 specimens, Rawson's Pass, Mt Kosciusko, N.S.W., 6,800 ft, 7.I.1929, W. Boardman, A.M. W. 2654.

Cryptodrilus tenuis Fletcher, 1889

Fig. 4B; 7D

Cryptodrilus tenuis Fletcher, 1889: 1543–1544.

Trinephrus tenuis; Beddard, 1895: 483.—Michaelsen, 1900: 185.

Cryptodrilus tenuis; Jamieson, 1972b: 159–161; Fig. 4B, 6F, 7D.

Augmented diagnosis: l = 85–99 mm, w = 2.5 mm, s = 156, 196.

Prostomium tanylobous. First dorsal pore 9/10 or more posterior. Setae in 8 regular longitudinal rows throughout; *aa: ab: bc: cd: dd: u* = 14.8: 5.9:16.8:11.2:17.6:100 (mean of 2 paralectotypes; Braidwood); 11.9: 5.3:15.0:11.5: 24.2:100 (mean of 3, Kosciusko). Nephropores in *a*, *bc* and *d* lines in V posteriorly and in *a* and *d* lines in II–IV. Clitellum annular, XIII, 1/3 XIII–XVII, XVIII (= 4 2/3-6 segments). A pair of combined male and prostatic pores on large or indistinct papillae, in the setal arc of XVIII, in *ab*. Accessory genital field consisting typically of paired eye-like glandular areas or tumescences in *a* lines, in 17/18, 18/19 and 19/20 with (Kosciusko) 3 pairs of additional markings, in 15/16 and 16/17 and posteriorly in IX. Female pores shortly antero-median of setae *a* of XIV. Spermathecal pores in 7/8 and 8/9, in *a* lines.

Dorsal blood vessel single; last hearts in XII. Gizzard moderately well developed in V; oesophagus with annular, medianly grooved calciferous(?) dilatations in XIV and XV. Intestine commencing in XVII; typhlosole absent (?). Nephridial bladders one at each pore, elongate-ovoid, some of which receive more than one nephridial duct in X anteriorly; tufted vesiculate nephridia present in II–VI. Nephrostomes unknown. Testes and funnels free in X and XI; seminal vesicles in IX and XII. Prostates slenderly tubular each with a simple duct which is joined by the vas deferens at some distance from the gland. Penial setae absent. Ovaries and funnels in XIII; ovisacs present in XIV. Spermathecae 2 mm long, duct approximately half of this; clavate diverticulum joining the midlength of the duct and one fourth or less of the total length of the spermatheca.

Material examined: 2, 3 severely macerated posterior amputees (A.M., W. 4694. CSIRO).

Wider distribution: Braidwood, New South Wales.

Remarks: The Mount Kosciusko material differs from the type-specimens from adjacent Braidwood in the smaller extent of the clitellum (1/3 XIII–XVII), in the additional genital markings and the smaller male porophores.

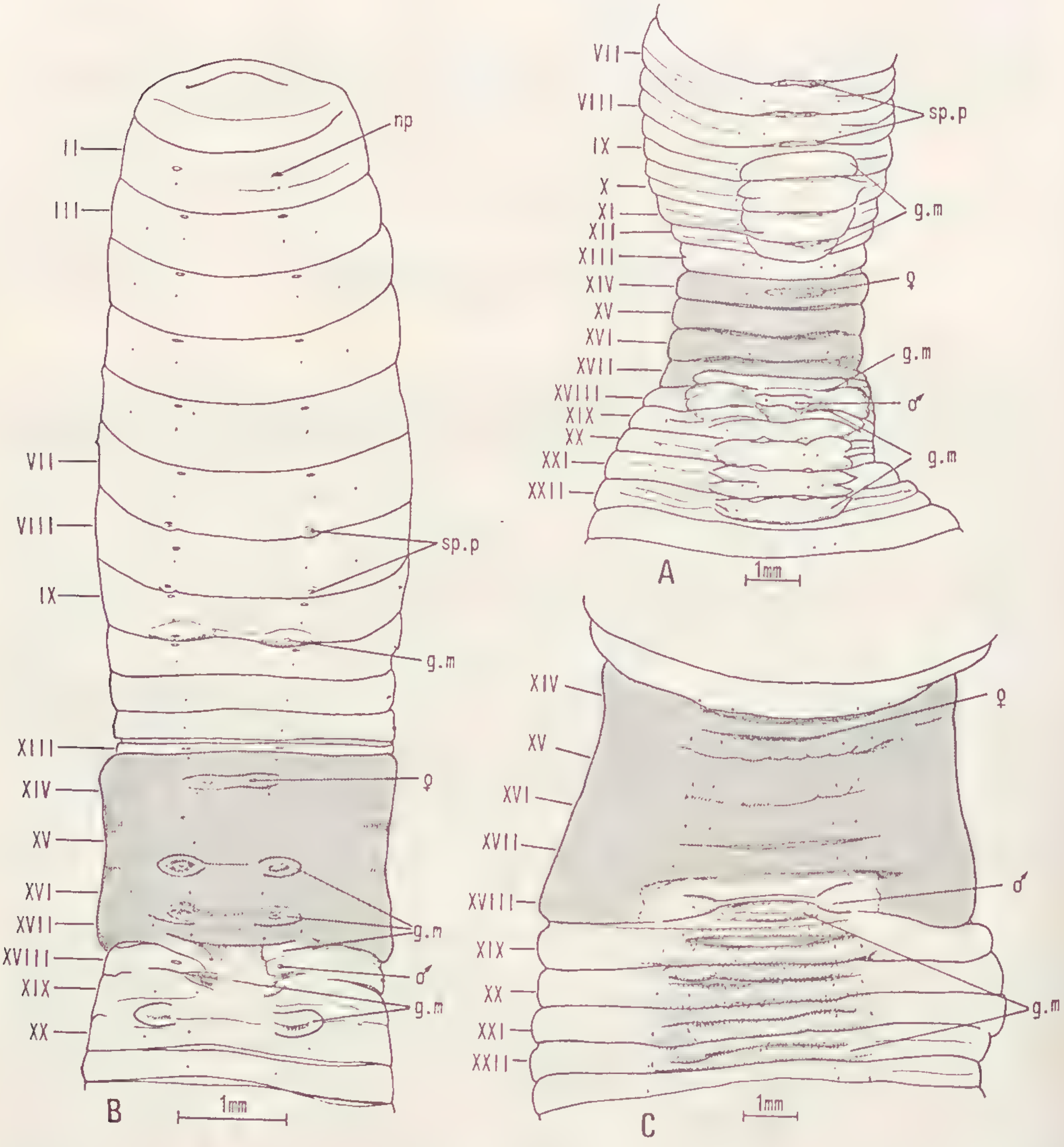


Figure 4.—Genital fields of: A, *Graliophilus montiskosciuskoi* sp. nov., holotype, 9/1. B, *Cryptodrilus tenuis* Fletcher, 1889, specimen 1, 2. C, *Notoscolex montiskosciuskoi* sp. nov., holotype, 12/2. By camera lucida. Clitellum shaded.

INTERSETAL DISTANCES IN SEGMENT XII
In *Cryptodrilus tenuis*

	aa		ab		bc		cd	
	mm	st	mm	st	mm	st	mm	st
Specimens 1 ..	0.91	11.06	0.42	5.11	1.19	14.47	0.91	11.06
2 ..	0.95	12.68	0.42	5.63	1.12	15.02	0.88	11.74
3 ..	0.88	11.96	0.39	5.26	1.19	16.27	0.88	11.96
mean		11.90		5.33		15.25		11.59
intervals/ab ..		2.23		1.00		2.86		2.17
mean, paralectotypes 1 and 2.		14.79		5.88		16.98		11.35
intervals/ab ..		2.52		1.00		2.89		1.93

	dd		dc		cb		ba	
	mm	st	mm	st	mm	st	mm	st
Specimens 1 ..	2.28	27.66	0.91	11.06	1.19	14.47	0.42	5.11
2 ..	1.68	22.54	0.88	11.74	1.12	15.02	0.42	5.63
3 ..	1.65	22.49	0.84	11.48	1.12	15.31	0.39	5.26
mean		24.23		11.43		14.93		5.33
intervals/ab ..		4.55		2.14		2.80		1.00
mean, paralectotypes 1 and 2.		17.55		11.03		16.58		5.88
intervals/ab ..		2.98		1.88		2.82		1.00

General anatomy in samples from the two areas conforms and, with the doubtful exception of *dd*, setal ratios are not significantly different. It is probable that the two samples are drawn from the same infraspecific population.

Dorsal pores were not observable, presumably because of maceration. Internal anatomy in the single Kosciusko specimen dissected (locality *2*) agreed in all respects with the description of Jamieson (1972c) but the macerated condition of the specimen precluded elucidation of dorsoventral commissural vessels anterior to VIII and, although an exact agreement in distribution of nephridial bladders was found, the finer morphology of the nephridia was not investigated. Dimensions of the right spermatheca of IX (illustrated) are: length 1.6 mm; ratio total length : length duct 1.8; ratio total length : length diverticulum 5.1, small variations from the types. The Kosciusko specimen provides the additional information on junction of vasa deferentia and prostate ducts.

Tribe **DICHOGASTRINI** Jamieson, 1971a
Genus **Notoscolex** Fletcher, 1887

The author (Jamieson, 1971c, 1972a) has drawn attention to heterogeneity in *Notoscolex* which exceeds that to be expected in a genus. In the latter paper, in which the type-species, *N. camdenensis*, was redescribed, a basis was presented for restriction of the genus. Of four species which it was suggested might be included with *N. camdenensis* in a restricted *Notoscolex*, *Cryptodrilus fastigatus* must be removed as re-examination has shown (Jamieson, 1972b) that it is referable to a reinstated genus *Cryptodrilus* Fletcher, 1887 which is diagnosed by multiple nephridial bladders.

Formal restriction of *Notoscolex* is, however, deferred pending revision of at least the Australian species. The following Mt Kosciusko species is placed, therefore, in *Notoscolex* s. lat. as it conforms with the superficial diagnosis of the genus in having 8 setae per segment, prostates with branched ducts, and meronephridia while not showing sufficient differences from the type-species to unequivocally warrant establishment of a new genus on present evidence. Location of calciferous glands in IX–XIII nevertheless excludes it from the group of species to which *N. camdenensis* belongs (calciferous glands in XIV–XVI) and may later support generic distinction.

In the present account a further species which conforms with the abovementioned diagnosis of *Notoscolex* can confidently be excluded from the genus as it shows the megascolecin condition of the nephridia and not the dichogastrin condition seen in *N. camdenensis* and *N. montiskosciuskoi.*

Notoscolex montiskosciuskoi sp. nov.

Fig. 4C; 6E; 7E

l = 80, 99 mm, w (midclitellar) = 9 mm, s = 151, 149 (holotype and paratype 1 respectively). Form stout, the anterior end clubbed though apically tapering, the clitellar region constricted; circular in cross section throughout; segments weakly biannulate, excepting the first few which are simple. Pigmentless buff in alcohol with the exception of the clitellum, which is pigmented pale brown. Prostomium tanylobous (holotype and 3 paratypes), or epilobous 1/2 with the peristomium much grooved (6 paratypes) with very narrow, posteriorly narrowing dorsal tongue. First dorsal pore 3/4 (9 specimens). Setae minute, in 8 longitudinal rows, commencing on II, becoming scattered posteriorly; *a* and *b* absent in XVIII.

INTERSETAL DISTANCES IN SEGMENT XII

In *Notoscolex montiskosciuskoi*

	aa		ab		bc		cd	
	mm	st	mm	st	mm	st	mm	st
Holotype	2.21	10.44	0.57	2.69	2.64	12.46	2.71	12.79
Paratype 1	3.36	11.35	0.64	2.17	3.57	12.08	3.07	10.39
2	2.43	8.72	0.64	2.31	2.64	9.49	4.21	15.13
3	2.07	11.20	0.50	2.70	2.43	13.13	1.57	8.49
4	1.36	6.55	0.57	2.76	2.64	12.76	2.50	12.07
5	2.14	10.10	0.71	3.37	2.93	13.80	1.50	7.07
6	2.14	10.24	0.50	2.39	2.43	11.60	2.43	11.60
mean		9.80		2.63		12.19		11.08
interval/ab		3.73		1.00		4.63		4.21

	dd		dc		cb		ba	
	mm	st	mm	st	mm	st	mm	st
Holotype	7.21	34.01	2.79	13.13	2.50	11.78	0.57	2.69
Paratype 1	11.64	39.37	3.07	10.39	3.57	12.08	0.64	2.17
2	10.93	39.23	3.50	12.56	2.86	10.26	0.64	2.31
3	6.93	37.45	2.07	11.20	2.43	13.13	0.50	2.70
4	8.14	39.31	2.36	11.38	2.57	12.41	0.57	2.76
5	8.43	39.73	1.86	8.75	2.93	13.80	0.71	3.37
6	8.29	39.59	2.21	10.58	2.43	11.60	0.50	2.39
mean		38.38		11.14		12.15		2.63
interval/ab		14.59		4.24		4.62		1.00

Nephropores not externally visible. Clitellum annular, well developed but constricted relative to adjacent segments, embracing XIV–XVIII; intersegmental furrows retained only ventrally; dorsal pores visible but occluded; setae retained (holotype and 6 paratypes). Male pores on inconspicuous papillae in *a* lines (holotype and 4 paratypes). Genital markings consisting of ill defined transverse slightly tumid strips one in front of, the other behind the equators of segments XVIII–XXII; those in XVIII between the male papillae; those in XIX–XXII including setae *b* (holotype; paratype 7 very similar; in other paratypes less developed or more or less obscured by maceration). Female pores paired anteromedian to setae *a* (holotype and 5 paratypes). Spermathecal pores 4 pairs in 5/6–8/9, on small papillae in *ab* nearer *a* (holotype and 2 paratypes).

Internal anatomy (Holotype and paratype 2):

Septa: 4/5 delicate; 5/6 thin, backwardly displaced by the gizzard; 6/7 slightly thickened; 7/8 moderately thickened; 8/9–13/14 strongly thickened; the remainder thin. Last septal (pharyngeal) glands in IV. Dorsal blood vessel paired segmentally, unpaired at the septa and anterior to the commissurals of V; bifurcating to each side behind the brain. Dorsoventral commissural vessels in V–XII; those in V–IX dorsoventral only; very slender in V–VIII; forming slender hearts in IX; those in X–XII forming 3 pairs of large latero-oesophageal hearts, each arising from a transverse vessel which encircles the corresponding calciferous gland shortly before this vessel joins the supra-oesophageal vessel; origin from the dorsal vessel not certainly demonstrated. Supra-oesophageal vessel occupying VIII–XIII, receiving a pair of vessels in each segment from the calciferous glands; 2 pairs of vessels from the oesophagus in XIV join the dorsal vessel. Subneural vessel absent.

Gizzard large, globular, muscular but easily compressible, preceded by a swollen thin-walled proventriculus in V. Oesophagus in VI–VIII thin-walled and not appreciably vascularized; in each of segments IX–XIII bearing laterally a pair of calciferous glands each of which is approximately semicircular viewed in the body axis and is sessile on the oesophagus; the lumen of each gland traversed by very numerous densely packed delicate lamellae which occupy all but the central third of the lumen; the lumen continuous with that of the oesophagus via a circular constricted but fairly large orifice. Oesophagus in XIV and XV narrow and thin walled. Intestine commencing, with abrupt expansion, in XVI; typhlosole absent.

Meronephric (holotype and paratype 2); nephridia commencing in III; those in III–V forming very large tufts with composite ducts which pass forwards to open into the pharynx and buccal cavity, i.e., enteronephric tufted micromeronephridia. Those in VI posteriorly forming transverse bands of very numerous separate exonephric integumentary micromeronephridia. Posteriorly with transverse rows of astomate, integumentary micromeronephridia with, on each side of the nerve cord, a median stomate exonephric megameronephridium (holotype). Large iridescent sperm funnels and copious sperm masses free in X and XI; testes not detectable; small slightly lobulated seminal vesicles in IX and XII. Ovaries undetectable funnels in XIII; ovisacs pendant from the anterior septum of XIV (ovisacs not developed in paratype). Prostates externally intermediate between the racemose and tubular types; each (schizoparatype) with a main central lumen, bounded by a definite epithelium, which is surrounded by lobuli composed of groups of glandular cells which in some cases appear to radiate from narrow lumina lacking epithelia; the central lumen has numerous evaginations of its walls into the gland but these extend only a very short distance below the general level of the basement membrane and it was not possible to demonstrate continuity of the short lumen of each with the intercellular lumina in the gland. Each gland elongate and sinuous but ectally wide and lobulate, with a short slender duct; the vasa deferens joining the gland at its junction with the duct (holotype).

Penial setae gently bowed, ectally tapering, the ectal end drawn out into an indefinite flattened or ribbon-like flexible tip, most setae giving the appearance that the ectal end is degenerating; a few circlets of cicatricing present near the tip, consisting of minute ectally directed serrations produced by notching of the seta; the cicatricing in some setae hardly appreciable; length of a well developed penial seta = 0.94 (holotype) — 1.72 mm (mean of 5 specimens = 1.4 mm), greatest width (near base) = 23 — (holotype) 28 μ (mean of 5 specimens = 25 μ). Spermathecae 4 pairs opening anteriorly in their segments, each with an elongate-ovoid pointed ampulla, a poorly demarcated duct of approximately the same length, and a clavate iridescent diverticulum which joins the ectal end of the duct; size uniform, length of right spermatheca of IX = 3.2 mm; ratio total length: length duct = 2.1; ratio total length: length diverticulum = 3.9.

Material examined: 12/2 Holotype; *1/1* P2; *5/1* P3; *5/9* P4 A1; *9/1* P5 A2; *10/1* A2; *11/1* A1; *12/4* A1; *12/9* P6 A1; *17/6* A3; *22/1* A2; *23/1* P1. (H, A.M., W. 4683 P1–4, A.M., W. 4684–4687; P5, B.M., P6, B.J.; A, B.M., B.J., CSIRO).

Remarks: Four species approach *N. montiskosciuskoi* in general anatomy (*C. campestris* Spencer, 1895; *C. illawarrae* Fletcher, 1889; *C. mudgeanus* Fletcher, 1889 and *C. wellingtonensis* Spencer, 1895) but these have fewer pairs of spermathecae and differ in other respects including the male genital field which distinguishes *N. montiskosciuskoi* from all other species of *Notoscolex*.

Tribe **MEGASCOLECINI** Jamieson, 1971a

Genus **Oreoscolex** nov.

Setae 8 per segment commencing on II. Ventral setal couples moderately closely paired; dorsal couples (*cd*) widely paired, *cd* being only slightly smaller than the interval between the couples of a side (*bc*). A pair of combined male and prostatic pores on XVIII; accessory genital markings present in segments in their vicinity. Female pores on XIV, anteromedian of setae *a*. Spermathecal pores unpaired, midventral, posteriorly in VII and VIII. Latero-oesophageal hearts in X–XII, commissurals anterior to these purely dorsoventral. Supra-oesophageal vessel present, subneural absent. A large gizzard in V; oesophagus lacking extramural calciferous glands; intestine commencing in XVIII; a low dorsal typhlosole present. Nephridia numerous astomate, avesiculate exonephric micromeronephridia commencing in II, with in IV and V large (enteronephric?) tufts and smaller tufts in III (and in II?); caudally with numerous preseptal funnels in each segment (and enteronephric?). Testes and funnels in X and XI; testis-sacs absent; seminal vesicles in XII. Ovaries in XIII; ovisacs present. Prostates racemose, bipartite. Spermathecae unpaired, diverticulate.

Diagnosis: Combined pores of vasa deferentia and racemose prostates on XVIII. Gizzard in V; extramural calciferous glands absent. Nephridia astomate, avesiculate, exonephric micromeronephridia associated in anterior segments with (enteronephric?) tufts; caudally with numerous preseptally stomate (enteronephric?) micromeronephridia in each segment.

Distribution: Kosciuskan Division, Southern Faunal Province of Australia (Mt Kosciusko, New South Wales).

Monotypic. Type-species: *Oreoscolex imparicystis* sp. nov.

Remarks: Lumbricin setae, racemose prostates and meronephridia would formerly have warranted inclusion of the type-species in *Notoscolex* Fletcher. However, it has been suggested (Jamieson, 1972a) that *Notoscolex* should be restricted to species with extramural calciferous glands in segments XIV–XVI; a stomate nephridium median to micromeronephridia on each side in posterior segments (the Dichogastrin arrangement) and no intestinal typhlosole. The multiple caudal nephrostomes of *Oreoscolex* place it in the tribe Megascolecini.

The unpaired condition of the spermathecae is rare in the Megascolecidae but whether it is a generic character (as in *Fletcherodrilus*) or a merely specific character (as in *Pygmaeodrilus*) can only be decided if further species of *Oreoscolex* are found.

Oreoscolex imparicystis sp. nov.

Fig. 5A, B; 6G; 7G

External morphology (Holotype and paratypes 1–3 unless otherwise indicated):

l = 122–152 mm; w (midclitellar) = 5 mm; s = 120–188 (paratypes 2 and 3). Form slender, circular in cross section, secondary annulation significantly developed in the hindbody only; pigmentless in alcohol excepting the pale brown clitellum. Prostomium epilobous 1/3, forming an indistinctly marked equilateral triangle. Dorsal or other canalicula absent. First dorsal pore 3/4. Setae small, in 8 longitudinal rows; all setae of XVIII retained.

INTERSETAL DISTANCES IN SEGMENT XII

In *Oreoscolex imparicystis*

	aa		ab		bc		cd	
	mm	st	mm	st	mm	st	mm	st
Holotype	1.86	14.29	0.43	3.30	2.07	15.93	1.57	12.09
Paratype 2 ..	1.14	12.03	0.43	4.51	1.21	12.78	1.29	13.53
mean		13.16		3.91		14.36		12.81
interval/ab ..		3.37		1.00		3.67		3.28

	dd		dc		cb		ba	
	mm	st	mm	st	mm	st	mm	st
Holotype	3.00	23.08	1.71	13.19	1.93	14.84	0.43	3.30
Paratype 2 ..	2.50	26.32	1.29	13.53	1.21	12.78	0.43	4.51
mean		24.70		13.36		13.81		3.91
interval/ab ..		6.32		3.42		3.53		1.00

Nephropores not externally visible. Clitellum annular, moderately tumid in XIV–XVII but also occupying the posterior half of XIII; some clitellar modification of XVIII also appearing to be present in the holotype; dorsal pores retained at 13/14 and 17/18, at which the intersegmental furrows are clearly discernible, absent in the intervening region in which intersegmental furrows are almost inappreciable. A pair of combined male and prostatic pores situated near the posterior limit of XVIII median of *a* lines, each with slightly tumid lips which hardly constitute a porophore but lying in a glandular area which medianly approaches the ventral midline and laterally joins the corresponding accessory genital markings. The genital markings in the holotype consisting of 4 pairs of low but conspicuous approximately oval tumescences, a pair in each of intersegments 17/18, 18/19, 19/20 and 20/21 in *ab*, each marking bearing 2 dark, translucent pore-like depressions, one anterior to, the other posterior to the intersegment; the intersegmental furrows contiguous with the lateral border of the marking or incising it more or less deeply, 18/19 forming a deep trench-like depression separating the marking into anterior and posterior portions which are discrete except for median confluence with the glandular area around the male pores.

Of 11 specimens, from the four samples, in which the genital markings were examinable, all had the anterior portion at 17/18 and anterior and posterior portions at 18/19 and 19/20; 3 lacked the posterior portion at 17/18, and 5 lacked both the anterior and the posterior portions at 20/21. In several the anterior and posterior portions of a side at an intersegment were more widely separated than in the holotype. In some of the specimens, additional minor pores were present on the anterior portion of the marking at 18/19.

Female pores minute, a pair anteromedian of setae *a* of XIV, at approximately 1/3 *aa*. Spermathecal pores one in each of segments VII and VIII, each distinctly visible on a low, midventral, circular, domed porophore which is located in the posterior fourth of its segment but does not reach the posterior intersegment.

Internal anatomy (Holotype (H) and, where noted, paratypes 2 and 3).

Some preclitellar septa thickened; last septal (pharyngeal) glands in III, projecting into IV (H,P2, 3). Dorsal blood vessel single, continuous onto the pharynx. Dorsoventral commissural vessels in V (H)–XII, all valvular (H,P2, 3), those in X–XII forming 3 pairs of latero-oesophageal hearts; supra-oesophageal single in VII, VIII–1/2 XIII, weakly developed in XIII (H,P2,3) and in VII (P2). Slender latero-oesophageals, median to the hearts, in VII anteriorly become a pair of suboesophageals in VIII; no blood glands detectable (H). Subneural vessel absent (H). Gizzard in V very strongly muscular, firm, and cylindrical, unusually large, extending posteriorly as far as intersegment 8/9; attenuating and posteriorly deflecting septa 5/6–7/8 (H,P2, 3). Oesophagus moniliform and vascularized in VIII–XVII but lacking extramural calciferous glands; in VII virtually, and in more anterior segments totally supressed by development of the gizzard (H,P2, 3); especially swollen and vascularized in XIV–XVI in paratype 3. Oesophagus narrow to 1/2 XVIII at which the intestine begins; a low dorsal typhlosole present from about XX (H,P2, 3). Nephridia: very numerous, astomate, avesiculate exonephric integumentary micromeronephridia throughout most of the body with, median to these, in IV and V a large (enteronephric?) tuft on each side consisting of numerous spiral loops. Similar but much smaller tufts present in III and aggregations which may be tufts in II (H,P2, 3). Caudal segments with numerous micromeronephridia attached at the junction of septa and body wall anteriorly in their segments and with approximately 40 preseptal funnels on each side; possibly enteronephric as no ducts to the body wall were demonstrated (Paratype 3).

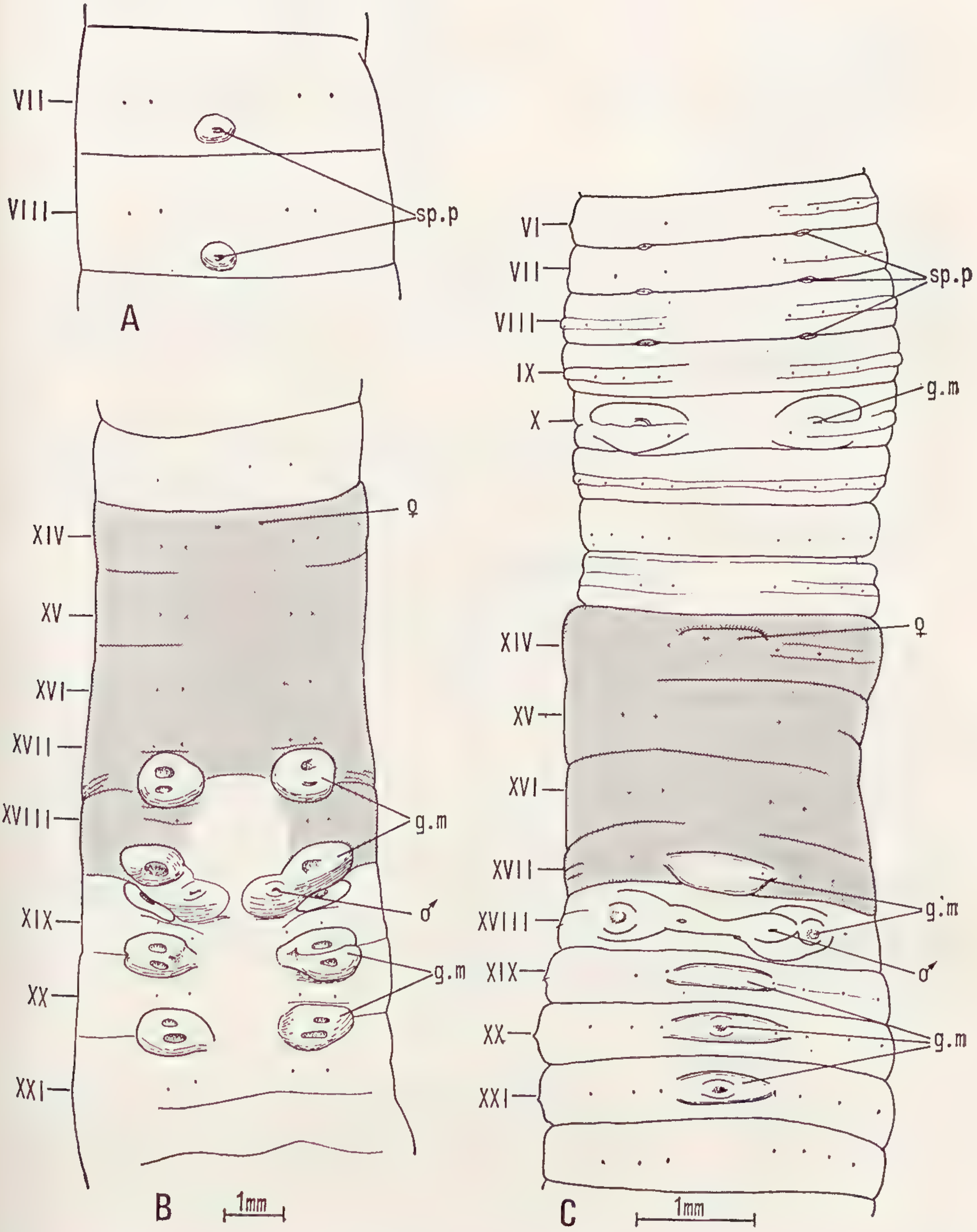


Figure 5.—*Oreoscolex imparicystis* sp. nov., holotype, 7. A, spermathecal pores. B, male genital field. C, male genital field of *Megascolex celmisiae* sp. nov., holotype, 19/8. By camera lucida. Clitellum shaded.

Testes? funnels? and iridescent sperm masses in X and XI (H, severely macerated); funnels iridescent in X and XI in paratypes 2 and 3; racemose seminal vesicles in XII only. Ovaries and funnels in XIII (H, P2, 3); racemose masses dependent from septum 13/14 into XIV in paratype 2 only, may be ovisacs. Prostates racemose, restricted to XVIII; the long duct bent posteriorly to enter the body wall immediately anterior to septum 18/19; the glandular part racemose and subdivided into an anterior and posterior portion, each with a number of distinct, themselves much-lobulated lobes; the duct bifurcated for a short ental region where it leaves the two main portions (H,P2, 3). Penial setae absent.

Spermathecae unpaired, in VIII and IX, each entering the body wall at the anterior border of its segment but preceded in the segment in front by a glandular cushion which corresponds with the low external porophore. Each spermatheca elongate, clavate, the ental swelling constituting a poorly demarcated ampulla; 2 subspherical diverticula sessile bilaterally at the anterior limit of the duct (H, P2,3). Length of the anterior and posterior spermatheca = 3.9 and 3.7 mm respectively; ratio total length:length duct = 1.8 and 1.9; ratio total length: mean length diverticulum = 6.8 and 7.4.

Material examined: *7* Holotype and P1; *12/1* P2, 3; *12/2* P4–9; *10* P10–12. (H. A.M., W. 4688 P1, 4–9, A.M., W. 4689–4690; P2, B.J.; P3, B.M.; P10–12, CSIRO).

Remarks: The male genital field of *Oreoscolex imparicystis* distinguishes it from all other Oligochaeta.

Genus **Megascolex** Templeton, 1844.

Megascolex celmisiae sp. nov.

Fig. 5C; 6H; 7F

External morphology (Holotype and paratypes 1 and 2, with additional specimens where indicated):

l = 42–54 mm (mean of 3 = 47.3 mm), w (midclitellar) = 3 mm, s = 99–111 (mean of 3 = 107). Form circular in cross section throughout; secondary annulation absent, or weakly developed behind the clitellum; prostomium epilobous >5/6, almost tanylobous; peristomium bifid ventrally; first dorsal pore 3/4. Setae commencing on II; numbers per segment 18–20 (mean = 19) on V; 20–21 (mean = 20) on XII; 19–20 (mean = 20) at 15–20 segments from the posterior end; *aa* a clearly recognizable interruption in the setal circle, *zz* not apparent as an interruption owing to its similarity to the distances between adjacent dorsal setae in each segment; setae *a* and *b* absent in XVIII.

INTERSETAL DISTANCES IN SEGMENT XII

Megascolex celmisiae

	aa		az		zz		za	
	mm	st	mm	st	mm	st	mm	st
Holotype	0.93	12.75	2.86	39.22	0.64	8.82	2.86	39.22
Paratype 3 ..	0.50	11.86	1.79	42.37	0.29	6.78	1.64	38.98
Paratype 4 ..	0.64	12.50	2.07	40.28	0.21	4.17	2.21	43.06
mean		12.37		40.62		6.59		40.42

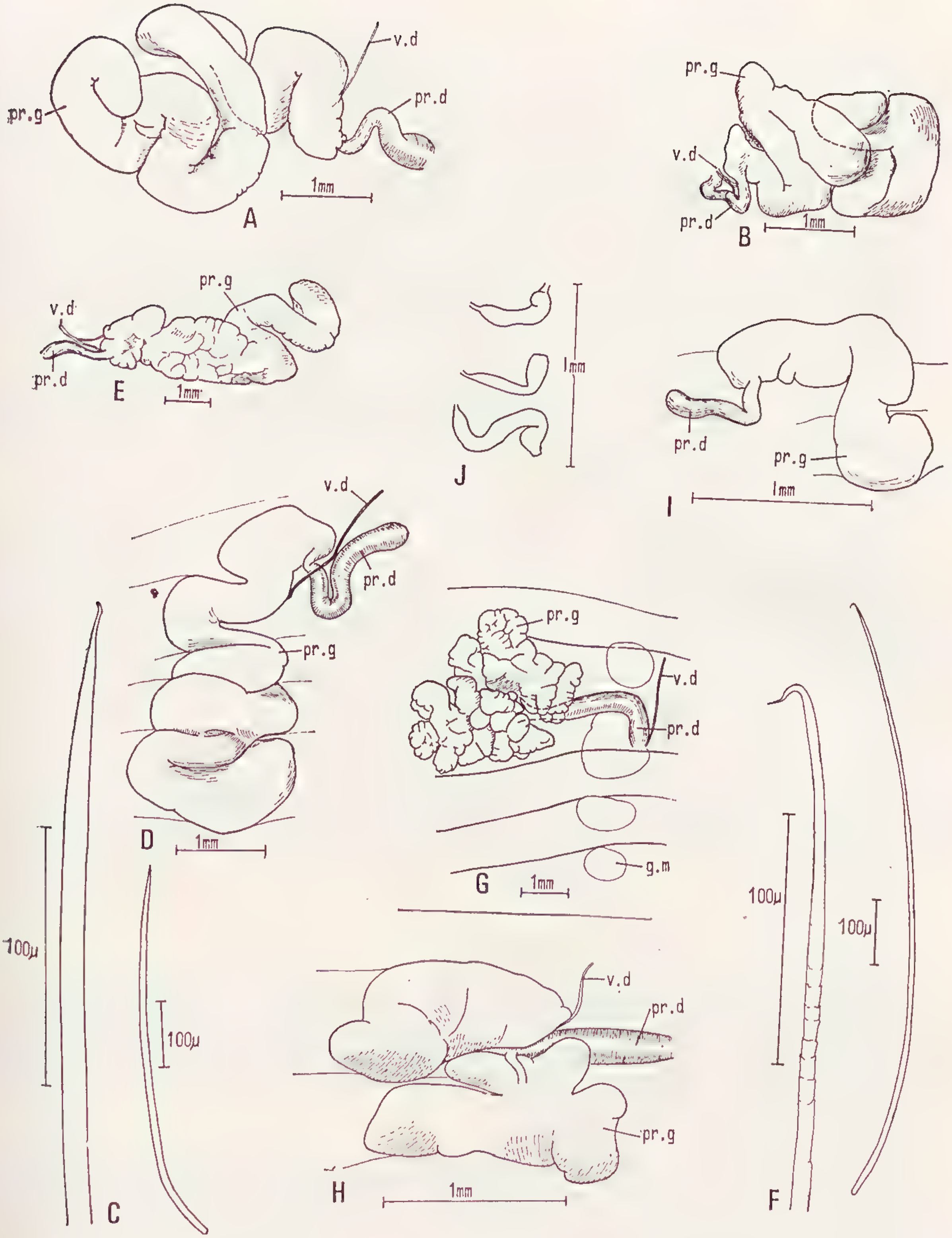


Figure 6.—Prostate glands, penial setae and nephridia of: A, *Graliophilus montiskosciuskoi* sp. nov., holotype, 9/1. B, *G. woodi* sp. nov., holotype, 19/2. C, *G. montiskosciuskoi* sp. nov., holotype, 9/1 (penial seta). D, *Vesiculodrilus purpureus* sp. nov., holotype, 5/1. E, *Notoscolex montiskosciuskoi* sp. nov., holotype, 12/2. F, penial seta of same. G. *Oreoscolex imparicystis* sp. nov., holotype, 7. H, *Megascolex celmisiae* sp. nov., holotype, 19/8. I, *Diprorochaeta pheretima* sp. nov., holotype, 12/3. J, nephridial vesicles of the same (pore to right) in, from top to bottom, VII, XIV and caudally By camera lucida.

Nephropores not visible. Clitellum annular, tumid but not appreciably protuberant, embracing XIV–XVII, weaker in the posterior half of XVII; weak clitellar modification to 1/2 XIII present dorsally; dorsal pores absent, intersegmental furrows and setae less visible than elsewhere. Male genital field (holotype): small slit-like combined male and prostatic pores a pair on XVIII in *ab* nearer *a*, each on a small papilla, the two papillae conjoined midventrally; accessory genital markings unpaired midventral transverse bands, extending laterally to include or almost reach setae *a*, one in each of segments XVII, XIX, XX and XXI; that in XVII mostly postsetal; those in XIX–XXI each mostly presetal; those in XVII and XIX smooth surfaced while those in XX and XXI have each a pore-like centre; a pair of accessory genital markings present in XVIII, immediately lateral to the male pores, each circular with a pore-like centre and lying on a low prominence which includes the male porophore; a further pair of low prominences present on X, centred on *ab*, filling the segment longitudinally, and with a presetal pore-like marking median to *b* line.

Variation in the distribution of accessory genital markings in the holotype and 26 paratypes, from most localities is shown in Table 2. To summarize, the only markings constant for all specimens are the smooth, midventral markings in XVII and XIX. Location of male pores was also constant. Midventral markings with pore-like centres may occur as far forward as XV or as posteriorly as XXII; the paired markings lateral of the male pores may be as in the holotype or may extend as longitudinal ridges ("circular" or "ridges" respectively in Table 2), or rarely may be transposed to lie in front of the male pores; additional paired pore-like markings may be present postsetally behind the presetal markings in X and, rarely, a pair of equatorial markings may be present near the ventral midline in XI. It is noteworthy that absence of midventral pore-like markings is strongly correlated with the presence of lateral ridges in XVIII and of postsetal markings in X. Animals exhibiting this correlation show no significant anatomical differences from, nor are they geographically segregated from, other specimens. They do, however, show a tendency to be larger and, if larger, have a better developed gizzard which deflects succeeding septa posteriorly. Female pores a pair of small but distinctly visible orifices shortly in front of the setal arc of XIV, median to *a* lines at about 1/3 *aa*. Spermathecal pores 3 pairs, in 6/7–8/9, in *ab* nearer *a*, not apparent unless the intersegmental furrow is held open (holotype).

Internal anatomy (Holotype, H, and paratype, P1):

Septa (H and P1 respectively where different): 3/4 thin; 4/5 and 5/6, or 4/5, slightly thickened; 6/7 to 13/14 or to 12/13 fairly strongly thickened; 14/15 moderately thickened and the remainder thin, or thin from 13/14 posteriorly. Paired large flocculent masses on each side of the alimentary canal in IV to VII (H) or to VIII (P1) are attached at the anterior septa.

Dorsal blood vessel single, continuous under the brain. Dorsoventral commissural vessels in VII–XII; those in X–XII forming 3 pairs of large latero-oesophageal hearts, each receiving its main connective from the supra-oesophageal vessel and a thin, filamentous connective from the dorsal vessel; commissurals in IX, anteriorly, slender and decreasing in width forwards. Supra-oesophageal vessel thin, in X to XII or (H) to anterior XIII, poorly developed.

Gizzard in V, globular, about one and a half times the width of the adjacent oesophagus, muscular but easily compressible, not displacing the septa of its segment. Oesophagus in VI–VIII, narrow, not evidently vascularized or moniliform; in IX–XIII much widened, moniliform and with circumferential vascular striae which are especially conspicuous in segment XII and XIII (H) or XIII (P1), probably owing to engorgement with blood at fixation and not structurally distinct; the entire vascularized region with numerous thick high internal folds, each fold surrounding an extension of the peripheral blood sinus; calciferous glands absent. Oesophagus narrow and not appreciably vascularized in XIV and XV. Intestine commencing, with abrupt expansion, in XVI; muscular thickening, typhlosole, and caeca absent.

Nephridia meronephric throughout; those in II–VI aggregated to form a group on each side, the group in V being especially large and forming a definite tufted nephridium the ducts of which, in the holotype, can be seen to run forward in a sheaf to join the lateral wall of the pharynx in segment III, being, therefore, enteronephric, astomate, pseudo-tufted nephridia; whether tufts in II–VI are exonephric or enteronephric has not been determined. Astomate (?), avesiculate integumentary micromeronephridia approximately 20 per segment in VII through the precaudal intestinal region; replaced in the posterior segments of the hindbody by stomate septal micromeronephridia, attached to the anterior septa of their segments and with several large ciliated preseptal funnels on each side in each segment; the ducts of these septal nephridia not traceable to the body wall but appearing to run medianwards in the septa and presumably enteronephric.

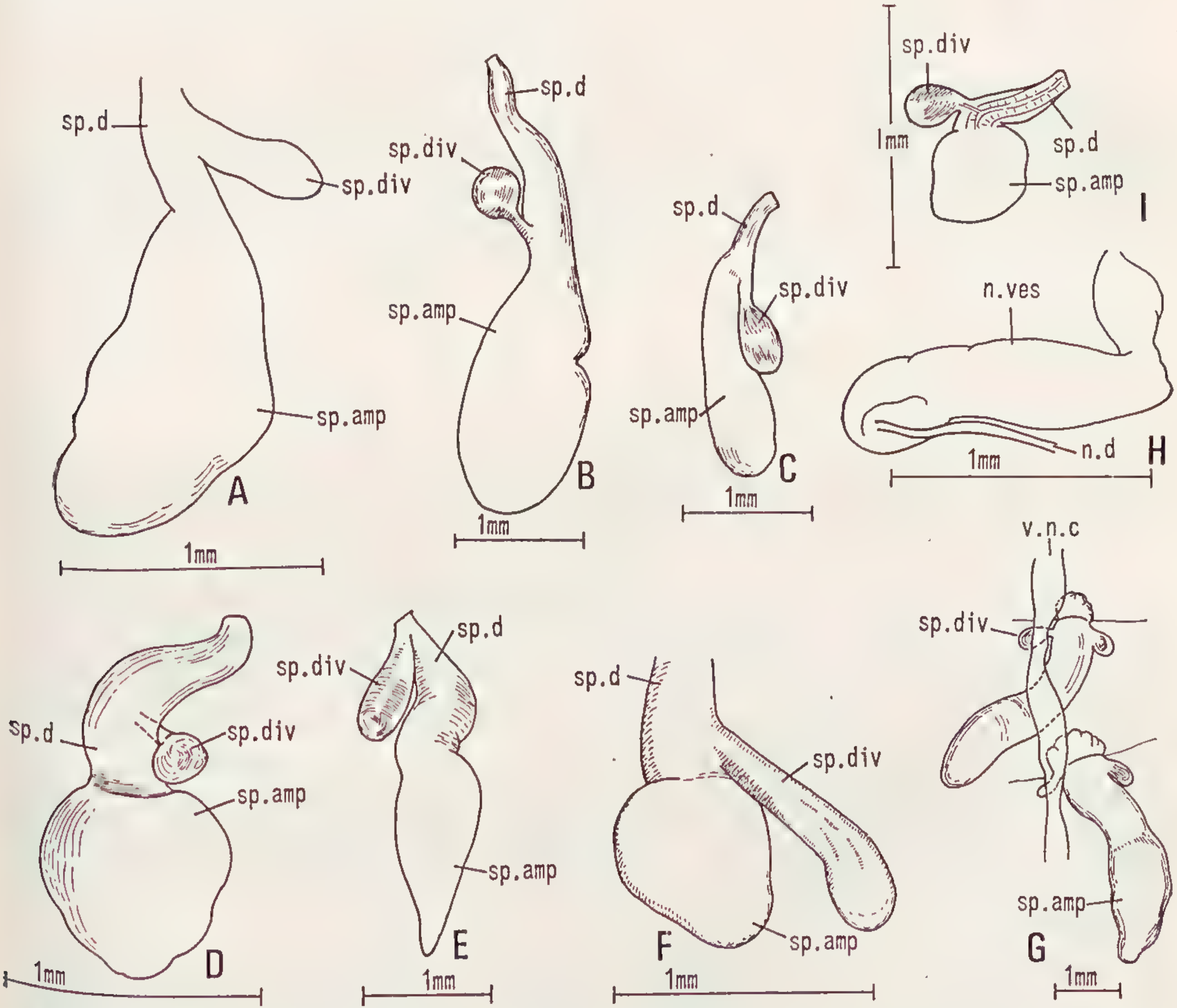


Figure 7.—A–G. Spermathecae of: A, *Graliophilus montiskosciuskoi* sp. nov., holotype, 9/1 (left IX). B, *G. woodi* sp. nov., holotype, 19/2 (right IX). C, *Vesiculodrilus purpureus* sp. nov., holotype, 5/1 (right VIII), D, *Cryptodrilus tenuis* Fletcher, 1889, 2 (right IX). E, *Notoscolex montiskosciuskoi* sp. nov., holotype, 12/2 (right IX). F, *Megascolex celmisiae* sp. nov., holotype, 19/8 (right IX). G, *Oreoscolex imparicystis* sp. nov., holotype, 7 (VIII and IX). H, left nephridial vesicle in XIV of *Vesiculodrilus purpureus* sp. nov., holotype. I, *Diporochaeta pheretima* sp. nov., holotype, 12/3 (right IX). By camera lucida.

Testes and large, weakly (if at all) iridescent sperm funnels free in X and XI; seminal vesicles racemose, with large loculi, in IX and XII, the anterior pair the larger. Ovaries large and conspicuous with several strings of oocytes, and funnels in XIII; ovisacs large, multiloculate, on the posterior face of septum 13/14. Prostates racemose, and bipartite, each consisting of 2 main lobes of which one lies in XVIII the other in XIX, the posterior lobe deeply incised in places but neither lobe with surface lobulations nor loculi; the wide medianly directed muscular duct almost as long as the transverse extent of the gland; vas deferens joining the anteromedian aspect of the anterior lobe. Penial setae absent. Spermathecae 3 pairs (H; only the right spermatheca of VII developed in P1), in VII–IX, each with a smoothly ovoid ampulla and a well demarcated, almost equally long narrow duct which is joined near its ental end (H) or further ectally (P1) by a lateral, elongate, terminally bulbous inseminated diverticulum which is only slightly shorter than the spermatheca. Length of the right spermatheca of IX (H) = 1.14 mm; ratio of total length:length duct = 2.41; ratio of total length:length diverticulum = 1.18.

Material examined: 19/8 Holotype; *5/9* P3; *6/1* A1; *11/1* P25, 26; *12/1* P9, 10 A3; *12/8* P11 A2; *13/1* P4 A2; *13/3* P5, 6, 7 A3; *13/4* P8; *14/1* P22 A1; *16/1* A3; *17/2* A1; *18/1* P21; *19/2* P1, 2 A2; *19/4* P12 A2; *19/5* P13, 14; *19/8* P15, 16 A1; *20/1* P19, 20 A8; *21/1* P17, 18 A4; *23/1* P23, 24 A5. (H, P1–20, A.M., W. 4662–2682; P21–23, +A, B.J.; P24, 25 + A, B.M.; P26 + A, CSIRO).

Remarks: M. celmisiae is distinguishable from all other species of *Megascolex* by its male genital field. It is unlikely that it is congeneric with the type-species of the genus, *M. caeruleus* Templeton, 1844, from Ceylon, which has rudimentary spermathecal diverticula and apparently lacks caudal enteronephry, but it must be referred to *Megascolex* pending revision of this large genus.

ZOOGEOGRAPHY

Suprageneric affinities

Of the three subfamilies of the Megascolecidae recognized by Jamieson (1971a), the Acanthodrilinae and Megascolecinae are indigenous in Australia though well represented elsewhere. The only Australian representative of the Ocnerodrilinae is the circummundane *Eukerria saltensis* (Beddard). The Acanthodrilinae, a subfamily of southern land masses and with very few extensions into the holarctic (Jamieson, 1971b), is poorly represented in Australia, where it is known only from the genus and small endemic subgenus *Diplotrema* and a few species of its second subgenus *Notiodrilus*, by two circummundane species of *Microscolex* and an endemic subantarctic species on Macquarie Island, and by a single Queensland species of the predominantly New Zealand genus *Rhododrilus*. No endemic Acanthodrilinae are known from Mt Kosciusko or neighbouring areas.

In contrast, the three tribes of the subfamily Megascolecinae are well represented in Australia and on Mt Kosciusko. The tribe Perionychini, which is more strongly represented in numbers of genera and species in Australia than elsewhere in its wide global range, is correspondingly well represented in the earthworm fauna of Mt Kosciusko and contains the great majority of its species. These species are assignable to the genera *Diporochaeta* Beddard, *Graliophilus* Jamieson, *Vesiculodrilus* gen. nov. and *Cryptodrilus* Fletcher.

The tribe Dichogastrini, of which only a small proportion of genera is indigenous in Australia is represented on Kosciusko only by *Notoscolex montiskosciuskoi.* The generically small tribe Megascolecini is a conspicuous element in the Australian fauna in numbers of species, but generic representation remains to be determined as the great majority of species are at present referred to the Ceylonese genus *Megascolex* with which they poorly accord. Until the erection of *Oreoscolex* in the present paper, none of the numerous Australian megascolecin species had been placed in an endemic genus. Apart from *Megascolex* s. lat. and *Oreoscolex*, each of which has a single species on Mt Kosciusko, the other Australian megascolecins are the non-dichogastrin portions of *Perissogaster* Fletcher (typical part), of *Notoscolex* Fletcher (excluding the type-species) and a single supposedly native Queensland species of the large Asian genus *Pheretima.*

Generic and specific affinities

A consideration of the distribution of the genera represented on Mt Kosciusko will elucidate the zoogeographic affinities of the fauna of the mountain with the remainder of the Australian earthworm fauna.

Diporochaeta

The single species of this genus known from Mt Kosciusko shows its closest affinities with several species of the genus from Victoria (which in turn are phenetically close to *Vesiculodrilus*) and it appears to have no close relationship with species occurring outside southeastern Australia. Beyond the Australian mainland, this heterogeneous and unsatisfactory genus is known from Tasmania, New Zealand and its associated islands and South India (Jamieson, 1971c).

Graliophilus

Graliophilus was erected by Jamieson (1971e) for Western Australian species of the genus *Plutellus.* The New South Wales species *Plutellus semicinctus* (Fletcher) appears to have close affinities with it and two Mt Kosciusko species are referable to it although showing distinctions which may later be considered generic. One, *G. montiskosciuskoi*, is known from only a single specimen collected in dry sclerophyll forest at 5,000 feet and the other, *G. woodi*, is common in, and restricted to, sub-alpine woodland and alpine herbfield between 5,800 and 6,900 feet. The distribution of *G. woodi* suggests that it is a cold-adapted species, a rare phenomenon in any group of Australian animals. Furthermore, as alpine conditions occur only in the Australian Alps, it is likely that this species is restricted to these mountains. Whether it is a glacial relict or a product of speciation in the alpine–subalpine zones is indeterminable. *G. montiskosciuskoi* may also be endemic in the Australian Alps.

Vesiculodrilus

This genus is restricted to Tasmania, Victoria and southern New South Wales, the Mt Kosciusko species being the only record from the latter State. Although *V. frenchi* is known only from a single site on Mt Kosciusko, at 6,200 feet in the alpine herbfield, it has also been recorded from adjacent East Gippsland in Victoria. Whether the new species, *V. purpureus*, known from the dry sclerophyll forest and subalpine woodland, occurs elsewhere than Mt Kosciusko is not known.

Cryptodrilus

Both Kosciusko species of *Cryptodrilus* have long been known elsewhere in New South Wales: *C. tenuis* from nearby Braidwood and *C. fastigatus* from Burrawang and Illawarra. This interesting genus, unique in the Oligochaeta in having more than two, and sometimes many, nephridial bladders in a segment, is restricted to Tasmania, Victoria and southern New South Wales, like *Vesiculodrilus*. The closest relatives of the genus appear to be those perionychins with vesiculate holonephridia. In Australia these are limited to the same regions or extend (*Heteroporodrilus*) into southern Queensland or (*Fletcherodrilus; Diporochaeta*) far north onto Cape York Peninsula.

The unparalleled diversity in the male genital field in *C. fastigatus* on Mt Kosciusko, which exceeds variation known in any other oligochaetes, merits further investigation. Possibly polytypic variation between isolates segregated by ice flows from the former cap glacier has survived as intra-population polymorphism following introgression of the former isolates. The occurence of this species above the winter snowline is remarkable.

Notoscolex

Jamieson (1971c) has drawn attention to the artificiality of the distinction between *Notoscolex* and *Megascolides* as currently defined, although confirming that the type-species are not congeneric, and has demonstrated the heterogeneity of each genus. The single species from Mt Kosciusko, *N. montiskosciuskoi*, resembles the type-species in being dichogastrin but the location of the calciferous glands excludes it from the same species-group and may later be shown to warrant exclusion from the same genus as the type-species. Of the four species which most closely resemble *N. montiskosciuskoi* anatomically, two occur in nearby parts of New South Wales and two in Tasmania. This reflects the zoogeographic affinities seen in other genera from Mt Kosciusko.

Oreoscolex

The megascolecin condition of the nephridia in the new genus *Oreoscolex* separates it widely from *Notoscolex*, in which *O. imparicystis* would formerly have been placed. Its affinities with the remainder of the Australian fauna are, however, little known, as few supposed *Notoscolex* species have been examined for the condition of the meronephridia and the latter genus is widespread in Australia.

Megascolex

Species assignable to this genus, as currently defined, have been found in all parts of Australia from which significant samples of earthworms have been obtained and therefore the presence of *M. celmisiae* on Mt Kosciusko tells us little of the faunistic affinities of the mountain. It must be noted, however, that as there is no evidence that the Australian species of *Megascolex* are congeneric with the Ceylonese type-species of the genus, close affinities of any part of Australia with the Oriental region must not be assumed. This is not to deny the possibility of a closer affinity between *Megascolex* in Australia and Oriental megascolecin oligochaetes than exists between it and non-megascolecin, e.g., dichogastrin, worms.

M. celmisiae has been almost as widely collected on Mt Kosciusko as *Cryptodrilus fastigatus* and, like the latter species, occurs in all vegetational zones. This suggests that it, too, may occur in other areas.

Conclusions

The zoogeographic affinities of Mt Kosciusko lie with the Southeast Australian mainland (adjacent New South Wales and Victoria) and Tasmania. The genera represented form a majority of the genera known from Tasmania. The latter island shares fewer genera with Western Australia and inclusion of Tasmania in the Western Subregion of Australia demonstrated numerically for the avifauna by Kikkawa and Pearse (1970) is not therefore supported by the distribution of earthworms. The earthworm fauna of Mt Kosciusko and that of Tasmania are an integral part of the Southern Province Faunula of the Kosciuskan Division of Australia's Eastern Subregion.

ACKNOWLEDGMENTS

The author is indebted to Dr T. G. Wood for the invitation to study the CSIRO collection and to Miss Elizabeth Pope for making available specimens from the collections of the Australian Museum. Thanks are due to Mr E. Bradbury for assistance in numerous respects. This work was made possible by tenure of Australian Research Grants Committee Grant No. 239280–R–ZOOL–ARGC–120–71.

REFERENCES

Beddard, F. E., 1888. Remarks upon a species of *Coccidium* infesting *Perichaeta*. *Ann. Mag. nat. Hist.* (6) 2: 434–439.

Beddard, F. E., 1890. Observations upon an American species of *Perichaeta* and upon some other members of the genus. *Proc. zool. Soc. Lond.* 1890: 52–69.

Beddard, F. E., 1895. A monograph of the order Oligochaeta. Clarendon Press, Oxford.

Benham, W. B., 1907. On the Oligochaeta from the Blue Lake, Mount Kosciusko. *Rec. Aust. Mus.* 6: 251–264.

Fletcher, J. J., 1887. Notes on Australian earthworms. Part I. *Proc. Linn. Soc. N.S.W.* (ser. 2) 1: 523–574.

Fletcher, J. J., 1889. Notes on Australian earthworms. Part V. *Proc. Linn. Soc. N.S.W.* (ser. 2) 3: 1521–1558.

Jamieson, B. G. M., 1971a. A review of the megascolecoid earthworm genera (Oligochaeta) of Australia. Part I—Reclassification and checklist of the megascolecoid genera of the world. *Proc. R. Soc. Qd* 82, 6: 75–86.

Jamieson, B. G. M., 1971b. A review of the megascolecoid earthworm genera (Oligochaeta) of Australia. Part II—The subfamilies Ocnerodrilinae and Acanthodrilinae. *Proc. R. Soc. Qd* 82 (8): 95–108.

Jamieson, B. G. M., 1971c. A review of the megascolecoid earthworm genera (Oligochaeta) of Australia. Part III—The subfamily Megascolecinae. *Mem. Qd Mus.* 16 (1): 69–102.

Jamieson, B. G. M., 1971d. Descriptions of the type-species of the genera *Digaster* and *Plutellus* (Megascolecidae: Oligochaeta). *Mem. Mus. natn. Hist. nat.*, Paris, Series 2 42 (6): 1300–1310.

Jamieson, B. G. M., 1971. Earthworms (Megascolecidae: Oligochaeta) from Western Australia and their zoogeography. *J. Zool., Lond.* 165: 471–504.

Jamieson, B. G. M., 1972a. Redescription of the type-species of the earthworm genus *Notoscolex* (Megascolecidae: Oligochaeta) *J. nat. Hist.* (In press).

Jamieson, B. G. M., 1972b. A numerical study of the Australian earthworm genera *Cryptodrilus* Fletcher and *Trinephrus* Beddard, with a new genus (Megascolecidae: Oligochaeta). *J. Linn. Soc.* 51 2: 147–175.

Jamieson, B. G. M., and E. A. Bradbury, 1972. Investigation of the Australian earthworm genus *Didymogaster* (Megascolecidae: Oligochaeta) and discrimination of populations by analysis of setal ratios. *Pedobiologia* 12: 111–122.

Kikkawa, J., and K. Pearse, 1969. Geographical distribution of land birds in Australia—a numerical analysis. *Aust. J. Zool.* 17: 821–840.

Michaelsen, W., 1891. Oligochaeten des Naturhistorischen Museums in Hamburg. IV. *Jb. hamb. wiss. Anst.* 8: 299–340.

Michaelsen, W., 1900. *Das Tierreich*, Vermes, Lief. 10, Oligochaeta. Friedländer, Berlin.

Spencer, W. B., 1892a. Preliminary description of Victorian earthworms. Part I. The genera *Cryptodrilus* and *Megascolides*. *Proc. R. Soc. Vict.* 4: 130–156.

Spencer, W. B., 1895. Preliminary notes on Tasmanian earthworms. *Proc. R. Soc. Vict.* 7: 33–54.

Spencer, W. B., 1900. Further descriptions of Australian earthworms, part I. *Proc. R. Soc. Vict.* (n.s.) 13 (1): 29–67.

Stephenson, J., 1933. Oligochaeta from Australia, North Carolina, and other parts of the world. *Proc. zool. Soc. Lond.* 1932: 899–941.

Sweet, G., 1900. On the structure of the spermiducal glands and associated parts in Australian earthworms. *J. Linn. Soc. Zool.* 28, 180: 109–139.

Templeton, R., 1844. Description of *Megascolex caeruleus*. *Proc. zool. Soc. Lond.* 12: 89–90.

Table 1

Localities sampled on Mt Kosciusko

(CSIRO collections)

Station		Diporochaeta pheretima	Graliophilus montiskosciuskoi	Graliophilus woodi	Vesiculodrilus frenchi	Vesiculodrilus purpureus	Cryptodrilus fastigatus	Cryptodrilus tenuis	Notoscolex montiskosciuskoi	Oreoscolex imparicystis	Megascolex celmisiae
	Dry Sclerophyll Forest										
1 and 2	*Eucalyptus pauciflora—E. stellulata—E. rubida*, 3,100 ft, near junction of Snowy and Thredbo Rivers—1/1, 16.v.1966; 2/A1, 12.v.1968; 2/A, 30.xi.1968.						+	+	+		
3	*Eucalyptus pauciflora—E. dives*, 3,750 ft, 30.xi.1968.										
4	*Eucalyptus pauciflora—E. dalrympleana*, 4,000 ft, Sawpit, soil and litter.										
5	*Eucalyptus pauciflora—E. dalrympleana*, 4,230 ft, near Sawpit. 5/1, 15.v.1965; 5/2, 18.xii.1966; 5/3, 20.iv.1967; 5/5, 10.xi.1967; 5/7, 15.ii.1968; 5/8, 25.viii.1968; 5/9, 30.xi.1968.					+	+		+		+
6	*Eucalyptus pauciflora—E. dalrympleana*, 12 m. East of Island Bend, 4,400 ft, 5.iii.1969.										+
7	*Eucalyptus pauciflora—E. dalrympleana*, 6 m. East of Island Bend, 4,400 ft, 5.iii.1969.									+	
8	*Eucalyptus pauciflora—E. dalrympleana*, 4,590 ft, near Wilson's Valley, 16.v.1966.						+				
9	*Eucalyptus pauciflora—E. dalrympleana*, 5,000 ft, 30.xi.1968.		+				+		+		
	Wet Sclerophyll Forest										
10	*Eucalyptus delegatensis*, 5 m. East of Island Bend, 4,000 ft, 5.iii.1969.						+		+	+	
11	*Eucalyptus delegatensis*, 3 m. East of Island Bend, 4,450 ft, 5.iii.1969.						+		+		+
12	*Eucalyptus delegatensis*, Wilson's Valley, 5,000 ft, 12/1, 15.v.1966; 12/2, 18.xii.1966; 12/3, 20.iv.1967; 12/4, 31.vii.1967; 12/7, 18.v.1968; 12/8, 25.v.1968; 12/9, 30.xi.1968.	+					+		+	+	+

Table 1 (*continued*)

Station		Diporochaeta pheretima	Graliophilus montiskosciuskoi	Graliophilus woodi	Vesiculodrilus frenchi	Vesiculodrilus purpureus	Cryptodrilus fastigatus	Cryptodrilus tenuis	Notoscolex montiskosciuskoi	Oreoscolex imparicystis	Megascolex celmisiae
	Sub-alpine Woodland										
13	*Eucalyptus pauciflora* with ground cover of *Poa-Celmisia*, Daner's Gap, 5,450 ft, 13/1, 16.v.1966; 13/2, 15.ii.1968; 13/2/A, 15.ii.1968; 13/2/B, 15.ii.1968; 13/3, 30.xi.1968; 13/4, 5.iii.1969.					+	+				+
14	*Eucalyptus pauciflora*, 5,850 ft, 5.iii.1969			+			+				+
15	*Poa—Celmisia* herbfield in *Eucalyptus pauciflora*, below Charlotte's Pass, 16.v.1966.										
16	*Eucalyptus pauciflora*, 6,050 ft, 5.iii.1969										+
	Alpine Herbfield										
17	*Poa caespitosa—Celmisia longifolia*, near Snowy River, 6,200 ft, 17/1, 20.iv.1967; 17/2, 10.xi.1967; 17/3, 15.ii.1968; 17/4, 19.v.1968; 17/5, 25.viii.1968; 17/6, 30.xi.1968.			+	+		+		+		+
18	*Poa—Celmisia*, 6,400 ft, 5.iii.1969			+			+				+
19	*Poa caespitosa—Celmisia longifolia*, near Seaman's Hut, 6,500 ft, 19/2, 20.iv.1967; 19/4, 10.xi.1967; 19/5, 15.ii.1968; 19/6, 19.v.1968; 19/8, 30.xi.1968.			+							+
20	*Poa—Celmisia*, 6,750 ft, 5.iii.1969										+
21	*Poa—Celmisia*, 6,900 ft, 20.iv.1967			+			+				+
22	*Poa caespitosa—Celmisia longifolia*, 6,990 ft, Rawson's Pass, 16.v.1966.						+		+		
23	*Poa—Celmisia*, 7,000 ft, 5.iii.1969						+		+		+
24	*Poa—Celmisia*, 7,100 ft, 5.iii.1969										
	Alpine Humus Soils on Granite										
25	6,000–6,400 ft, 10.ii.1968						+				

Table 2

DISTRIBUTION OF GENITAL MARKINGS IN THE HOLOTYPE AND 26 PARATYPES OF

Megascolex celmisiae

H — Holotype; P — Paratype

Genital Marking	Specimen	Total Number of Specimens
Paired porelike presetal in X	H P1, 4–6, 8–12, 14, 15, 17–19, 24–26.	18
Paired porelike postsetal in X	P3, 5, 6, 8, 10, 11, 26	7
Paired porelike midventrally in XI	P7	1
Midventral porelike in XV	P9	1
Midventral porelike in XVI	P4, 7, 9, 12–16, 18–20, 22–25	15
Midventral smooth in XVII	H P1–26	27
Paired porelike in *ab* of XVIII	P19	1
Paired porelike lateral to male pores in XVIII	H P1–4, 7, 9, 12–18, 20–25	20
Paired ridge lateral to male pores in XVIII	P5, 6, 8, 10, 11, 26	6
Midventral smooth in XIX	H P1–26	27
Midventral porelike in XX	H P1, 2, 4, 7, 9, 12–25	20
Midventral porelike in XXI	H P1, 2, 4, 7, 9, 12–21, 23–25	19
Midventral porelike in XXII	P4, 14	2

TYPTON AUSTRALIS SP. NOV., A NEW PONTONIINID SHRIMP FROM THE GREAT BARRIER REEF, AUSTRALIA

By A. J. BRUCE

East African Marine Fisheries Research Organization, Zanzibar*

NATIONAL MUS
22 JAN 197
OF VICTOR

Figures 1–4 Manuscript received 21st February, 1972

SUMMARY

A new species of pontoniinid shrimp from the Great Barrier Reef, Australia, is described and illustrated. The new species shows several morphological features intermediate between species of *Typton* and another spongicolous genus *Onycocaris* Nobili. The systematic affinities of the new species are discussed and the features which distinguish it from other species from the Pacific and western Indian Oceans and from the single American species, to which it is most closely similar, are noted.

INTRODUCTION

Until recently the genus *Typton* Costa, 1844, appeared not to be represented in the Indo-West-Pacific fauna. One species was known from the Mediterranean and eastern Atlantic coasts of Europe and Africa and several species were reported from tropical American waters. Several species are now known to live in association with sponges. The presence of *Typton* species in the Indo-West Pacific region was first recorded by Fujino and Miyake (1969) who reported *T. dentatus* from the Ryukyu Islands. A second species, *T. bawii*, from Zanzibar in the western Indian Ocean was later reported by Bruce (in press, b). The present report records the presence of a third species of *Typton* in the southern region of the area, on the Great Barrier reef. The genus *Typton* is therefore widely distributed in the Indo-West Pacific region, although apparently the species are naturally rare or difficult to collect.

---

* Present address: E.A.M.F.R.O., P.O. Box 81651, Mombasa, Kenya.

SYSTEMATICS

Typton australis sp. nov.

Figs 1–4

Material examined. 1 ovigerous female. Chinaman's Reef (between Opal and Rudder Reefs), Great Barrier Reef, Queensland, Australia, 10 ft, from dead coral. Coll. A. H. Banner, 15 January, 1968.

Description. A small pontoniinid shrimp with a subcylindrical body.

The carapace is smooth and slightly swollen. The rostrum is short, slightly depressed, and not reaching to the level of the cornea. The lamina is compressed and toothless. The tip is acute and slightly up-turned and the ventral border is strongly convex. There are no rostral setae. The orbit is obsolescent. The inferior orbital angle is absent and this region of the carapace shields the lateral aspect of the eyestalk. Supraorbital, hepatic and antennal spines are also absent. The antero-lateral angle of the carapace is produced and rounded, and exceeds the level of the tip of the rostrum. The posterior margin of the branchiostegite is broadly rounded.

The abdomen is smooth and enlarged. The segments proper are dorsoventrally flattened and the pleura are expanded laterally to enclose a large marsupial chamber. The third segment is not produced posteriorly in the dorsal midline. The fifth segment is 1.4 times the length of the sixth segment, which is strongly flattened, and about 1.7 times longer than deep. The posterior lateral angle of the sixth segment is strongly produced and acute. The posterior ventral angle is broadly expanded laterally, acute, with a convex lateral border.

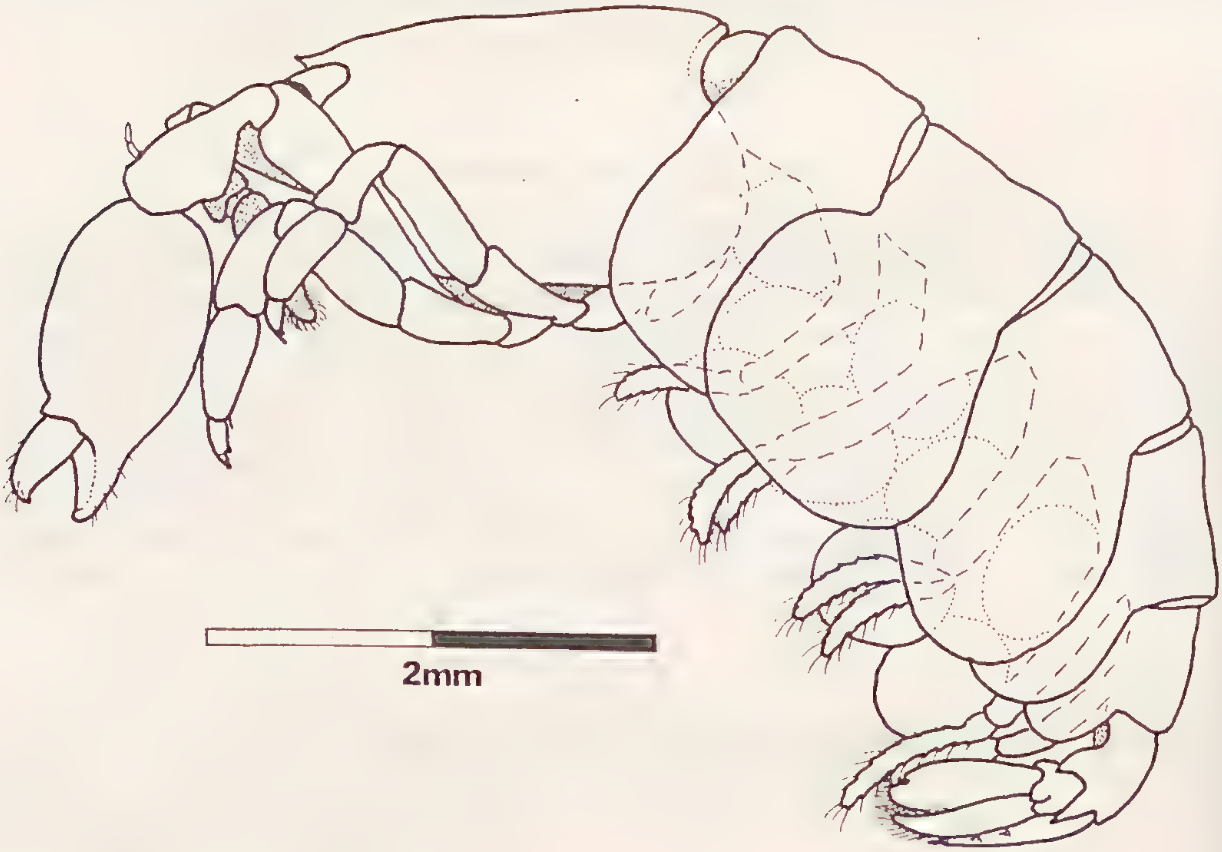


Figure 1. *Typton australis* sp. nov. Female, holotype

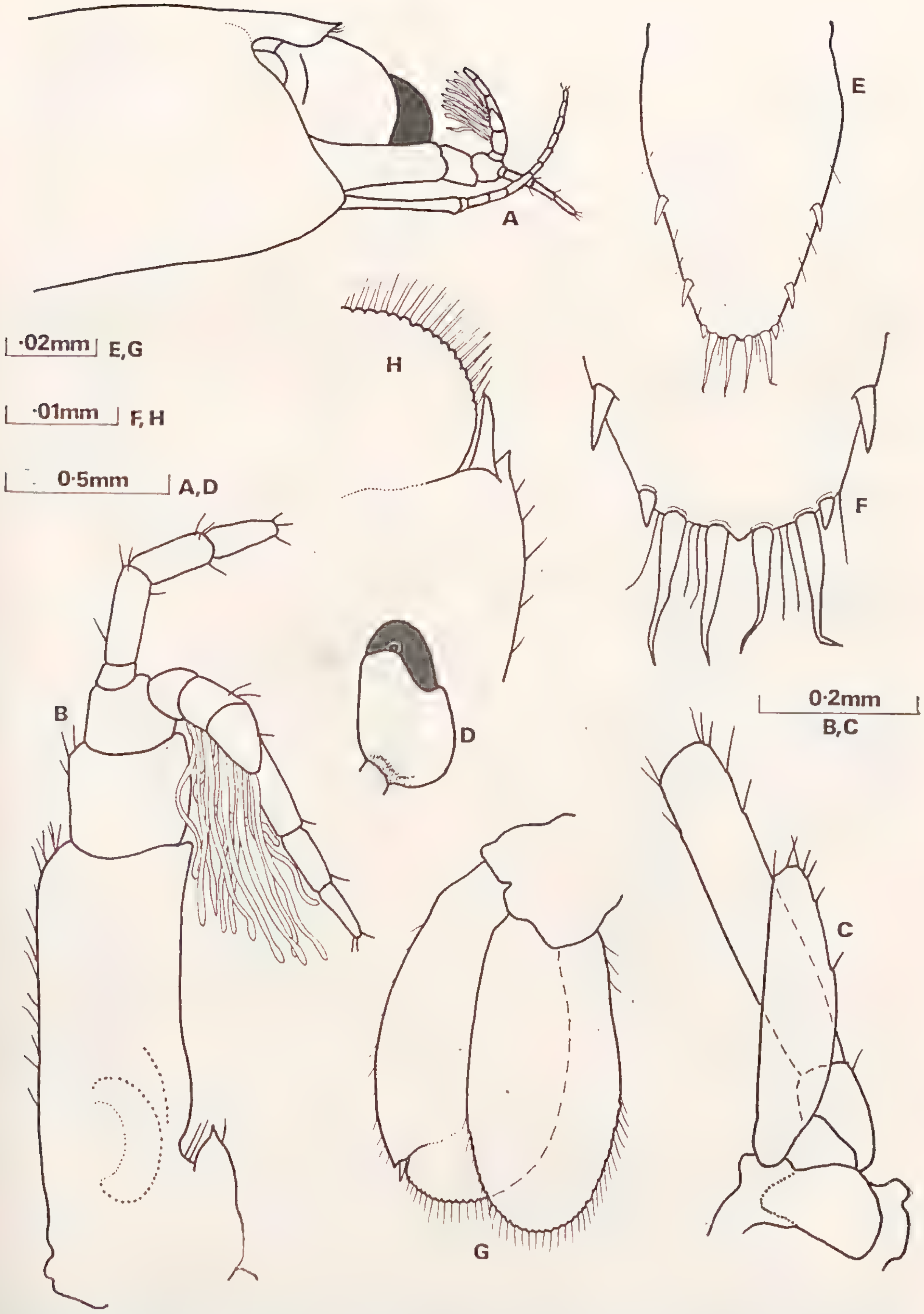


Figure 2. *Typton australis* sp. nov. Female, holotype. A, anterior carapace, right eye and antennae removed. B, antennule. C, antenna. D, eye, dorsal view. E, telson. F, termina telson spines. G, left uropod. H, disto-lateral spine of exopod of uropod

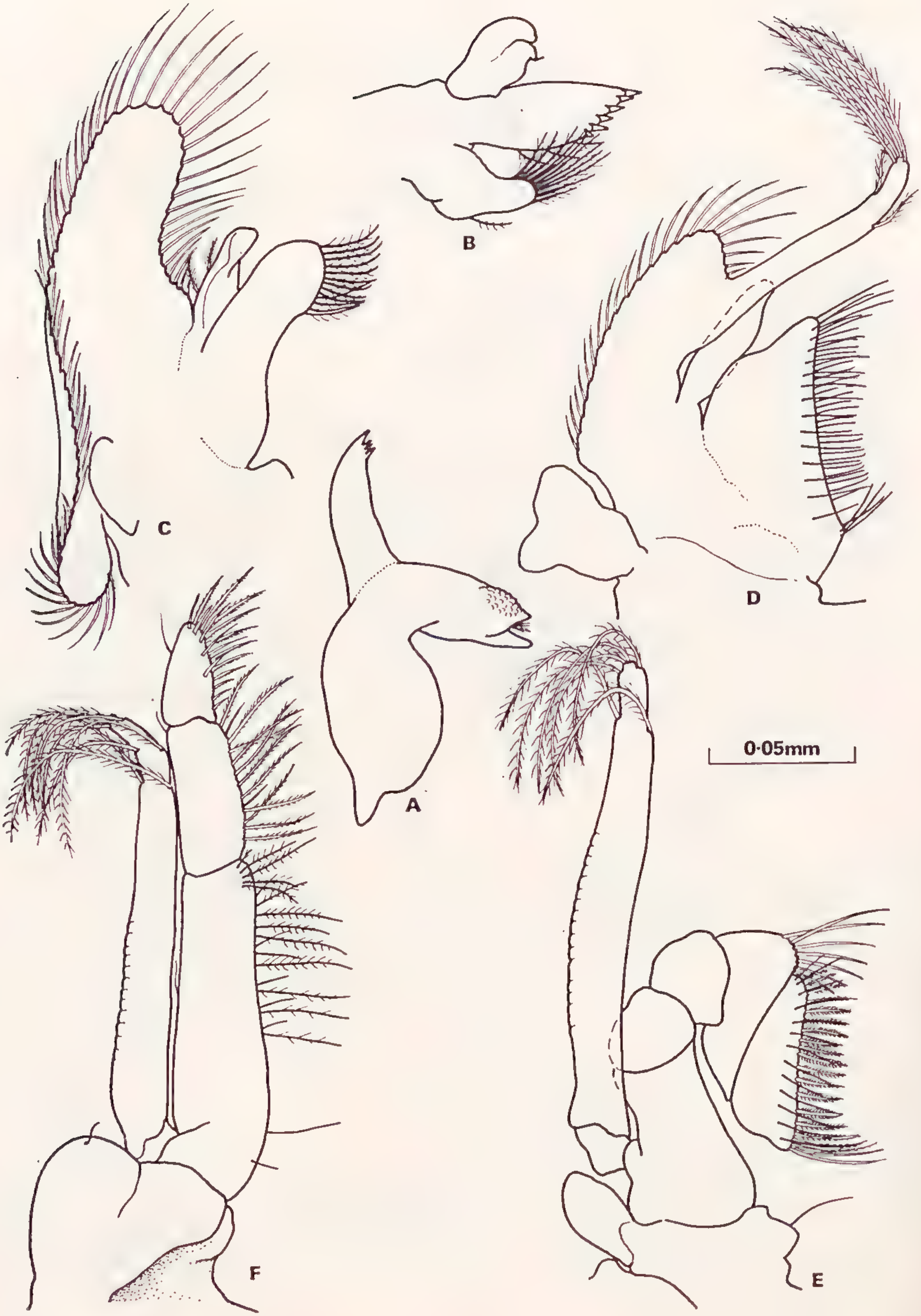


Figure 3. *Typton australis* sp. nov. Female, holotype. A, mandible. B, maxillula. C, maxilla. D, first maxilliped. E, second maxilliped. F, third maxilliped

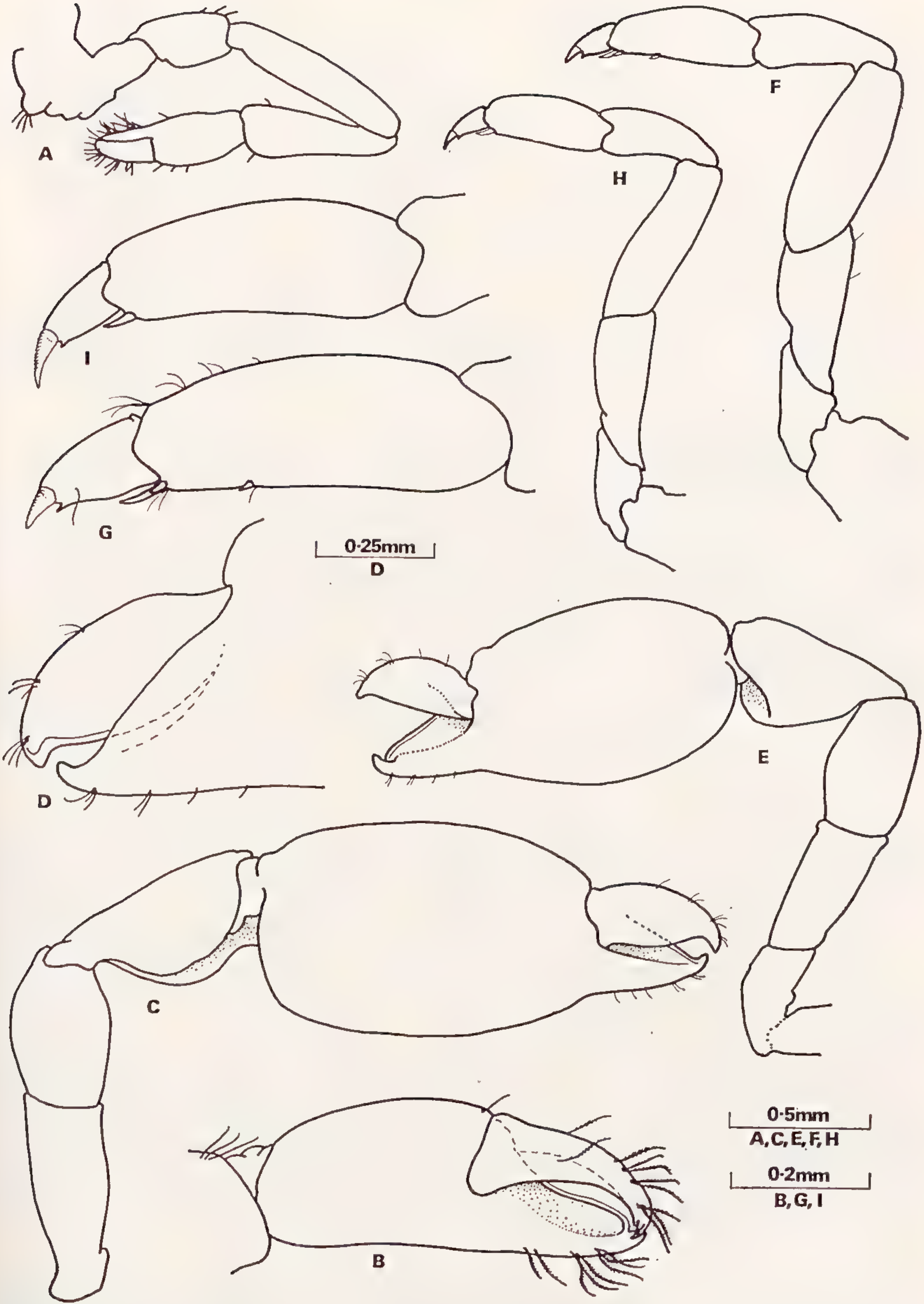


Figure 4. *Typton australis* sp. nov. Female, holotype. A, first pereiopod. B, chela of first pereiopod. C, major second pereiopod. D, fingers of major second pereiopod, lateral aspect. E, minor second pereiopod. F, third pereiopod. G, propod and dactyl of first pereiopod. H, fourth pereiopod. I, propod and dactyl of fourth pereiopod

The telson is broad, 1.5 times longer than wide, and tapering posteriorly. Anteriorly the lateral margins are convex and posteriorly almost straight. The posterior margin is about 0.4 times the anterior width, and is feebly rounded. Two pairs of subequal marginal dorsal spines are present, equal to about 0.1 of the telson length and situated at 0.56 and 0.85 of the telson length. Three pairs of terminal telson spines are present. The lateral spines are short and stout, equal to about half of the length of the dorsal spines. The intermediate telson spines are twice the length of the dorsal spines, slender, tapering and not swollen. The submedian spines are similar to the intermediate spines but slightly more slender. The posterior telson spines are separated by small intervals from which a few simple setae arise.

The eyes are well developed and extend far beyond the rostrum, reaching to the level of the anterior margin of the basal segment of the antennular peduncle. The eyestalk is stout, about 1.4 times longer than wide, and is subcylindrical, although strongly flattened medially and tapering distally. The cornea is hemispherical, markedly oblique and has a distinct accessory pigment spot dorsally.

The antennae are strongly reduced. The antennular peduncle exceeds the eye by the two distal segments. The basal segment is narrow, three times longer than wide, with subparallel sides. The stylocerite is short and feebly developed, not exceeding the proximal third of the length of the basal segment, with a short acute tip. The medial border is without a ventral spine and the disto-lateral angle is not produced and bears a small blunt process only. The statocyst is well developed but appears to lack any statolith. The intermediate segment is short, stout, subcylindrical, and equal to a little less than a quarter of the length of the intermediate segment and is also distinctly narrower. The lower antennular flagellum is very short and consists of only three stout subcylindrical segments. The upper flagellum is also markedly reduced. The two rami are fused proximally as one segment. The shorter free ramus consists of a single stout segment only and the longer free ramus is composed of three tapering subcylindrical segments only. Four groups of well developed aesthetascs are present.

The antenna is also strongly reduced. The basicerite is stout and unarmed. The carpocerite reaches to the middle of the intermediate segment of the antennular peduncle, and is strongly flattened, about 5.0 times longer than wide. The merocerite is stout and subcylindrical, equal to one third of the length of the carpocerite. The antennal flagellum is short, only slightly longer than the carpocerite and consists of nine segments. The scaphocerite is also reduced, reaching only to the middle of the carpocerite. The lamina is narrow, four times longer than wide, broadest centrally, and with a rounded tip. There is no disto-lateral spine and the anterior and medial margins bear a few short simple setae only.

The mouthparts present few special features. The epistome is normal and unarmed. The mandible has a short stout body, continuous with a robust molar process. The distal end of the molar process bears a slender blunt posterior tooth and a broad acute anterior tooth, with small squames on its inner aspect, and with some short simple setae between the two. The incisor process is well developed but slender and not robust, bearing four small acute teeth distally, of which the lateral tooth is distinctly larger than the other. The mandibular palp is absent.

The maxillula bears a short stout feebly bilobed palp, with a small seta distally on the inner lobe. The upper lacinia is narrow, obliquely truncated distally, with seven short stout spines along the distal border. A few sparsely plumose setae are also present along the medial border. The lower lacinia is short and stout, but not expanded, with ten slender, setulose setae distally.

The maxilla has a short stout palp which lacks any terminal or subterminal setae but bears two small plumose setae on its lateral border. The basal endite is well developed, simple, robust and broad distally. The distal margin is simple and bears thirteen slender, feebly setulose setae. There is no trace of a coxal endite. The scaphognathite is well developed and slender, about 3.2 times longer than broad.

The first maxilliped bears an elongated, non-setose palp. The coxal and basal endites are fused with no indication of any separation. The fused endite is broad generally but subacute disto-medially. The lateral border is emarginated near the middle of its length and the medial border is distinctly concave over the distal four fifths of its length, the proximal portion being slightly produced medially. The medial border bears numerous long slender simple setae in marginal and submarginal rows. A small group of four setae is also present on the proximal medial projection. The exopod is well developed, broad and flattened, with four long terminal and two short subterminal plumose setae. The caridean lobe is well developed and elongated and narrow. A feebly bilobed epipod is also present.

The second maxilliped is of normal form. The terminal segment is broadened distally and bears a row of stout strongly spinose spines along the medial border, with a submarginal row of slender setose setae. The penultimate segment is expanded proximally and bears seven slender spines on its antero-medial angle. The carpal segment has the proximal medial angle feebly produced. The ischium and basis are completely fused. The coxa bears a small triangular median process. The exopod is robustly developed, broad and flattened, with six well developed plumose distal setae. A small suboval epipod, without a podobranch, is also present.

The third maxilliped shows no special features. The basis is completely fused with the ischiomerus. The antepenultimate segment is slender, slightly tapering distally, about 3.4 times longer than broad. The medial border is sparsely provided with slender setulose setae. The penultimate segment is 2.25 times longer than broad and about half the length of the antepenultimate segment. The medial border is armed with more robust and densely setulose setae. The terminal segment is twice as long as broad and 0.3 times the length of the antepenultimate segment. The distal and medial borders are provided with numerous finely denticulate setae. The exopod is robustly developed, broad, and flattened, and exceeding the distal margin of the penultimate segment of the endopod. It bears eight well developed plumose setae distally. A rounded epipod is present but there is no arthrobranch.

The first pereiopod is moderately robust. The palm of the chela is subcylindrical, slightly compressed, 1.5 times longer than deep. The dactylus is about 0.8 times the length of the palm. The fingers are subspatulate, with laterally situated, entire, cutting edges. Distally each finger bears a larger medial and smaller lateral acute tooth. Numerous groups of finely serrated setae are present on the fingers. The carpus is about 1.1 times the length of the chela, three times longer than broad, and narrowed proximally. The merus is 1.2 times the length of the carpus and of uniform width. The ischium is slightly less than half the length of the merus. The basis is subequal to the ischium and the coxa bears a small rounded setose medial process. There is no median sternal spine on the fourth thoracic sternite.

The second pereiopods are small, similar, and slightly unequal. The palm of the larger second pereiopod is subcylindrical, swollen, slightly compressed, about 1.6 times longer than deep, and smooth. The fingers are short and compressed and the cutting edges oppose with a scissor-like action. The dactylus is about one third of the length of the palm. The dorsal border is convex and a strong subacute tooth is present distally. The cutting edge is convex, entire, and without any teeth. The fixed finger is triangular with a strong hooked distal tooth. The cutting edge is almost straight and entire throughout its length. The fingers bear a few groups of short setae. The carpus is stout, a little more than twice as long as broad, expanded and slightly excavated distally with unarmed distal margins. The merus is also stout and unarmed, about 1.5 times longer than broad, and 0.6 times longer than wide, and narrowed proximally. The smaller second pereiopod is generally similar to the larger except that the cutting edge of the dactylus is almost straight. The carpus is slightly shorter and less stout than in the major second pereiopod, as are also the merus and ischium. The coxa is without any median process.

The ambulatory pereiopods are robust. The third pereiopod extends anteriorly to exceed the carpocerite by the propod and dactylus. The dactylus is stout, about 2.2 times longer than its basal width. The unguis is distinct and acute, equal to about one third of the total length, and with small transverse furrows across the dorsal surface. The body of the dactylus is feebly compressed and bears a small acute accessory spine distally. The ventral border is otherwise entire. The propod is short and stout, about 2.5 times longer than the dactylus, and 2.9 times longer than broad, tapering slightly distally. The ventral border bears a long and a short distal spine, with another single short spine at about two thirds of its length. The carpus is subequal in length to the propodus, slightly tapered proximally, and unarmed. The merus is stout, 2.8 times longer than broad, and 1.25 times the length of the propod. The ventral margin is unarmed and devoid of spines. The ischium is broad and compressed, narrowed proximally and equal to 0.8 times the length of the merus. The basis is about 0.6 times the length of the merus and the coxa lacks any median process. The fourth pereiopod is generally similar to the third but is distinctly more slender and slightly shorter. The dactylus is similar but more slender, with a more acute unguis and a smaller accessory spine. The propod is more slender and bears only a single distal ventral spine. The fifth pereiopods are missing.

The pleopods are normal, with elongated peduncles and small narrow rami.

The uropods are normal. The basipodite is stout and unarmed. The exopod is broad, about 1.7 times longer than broad. The lateral border is strongly convex, entire, with a few marginal setae, and terminating in a small acute tooth with a large mobile spine medially. The exopod is also broad, and slightly narrower than the endopod, which it slightly exceeds.

The ova are large and few in number, about ten being still present.

Type. The single ovigerous female specimen available is designated as the holotype and is deposited in the collections of the Australian Museum, Sydney, Catalogue number AM P 17936.

Colour. No information is available. No persistent trace of colour pattern remains.

Measurements. Post orbital carapace length, 1.75 mm; total body length (approx.), 6.5 mm; length of chela of major second pereiopod, 1.6 mm; length of chela of minor second pereiopod, 1.3 mm; greater diameter of ovum, 0.63 mm.

Host. Unidentified.

Systematic position. The new species, *Typton australis*, appears to be most closely related to the tropical American species *T. tortugae* (McClendon) which is known from the Bermudas, Florida, and the Gulf of California (Holthuis, 1951a), rather than to the two known Indo-West-Pacific species.

In *T. tortugae* the orbit is feebly developed and lacks the large para-orbital spines found in most species of *Typton*. The eyes, antennae, mouthparts and pereiopods are all generally similar to those of *T. australis*. Points of difference between the two species are enumerated below:

T. australis	*T. tortugae*
1. Inferior orbital angle completely absent.	Inferior orbital angle (?)slightly produced.
2. Antennular flagella greatly reduced, fused portion of rami unisegmented.	Antennular flagella less reduced, fused portion of rami of 5–6 segments.
3. Scaphocerite reduced but reaching to middle of carpocerite.	Scaphocerite greatly reduced, not reaching to proximal end of carpocerite.
4. Maxillula with upper lacinia slender.	Maxillula with upper lacinia broad.
5. Maxilla with basal endite simple.	Maxilla with basal endite deeply bifid.
6. Second pereiopod with dactylus not semicircular, elongated; both fingers without teeth; merus without ventral spinulation.	Second pereiopods with dactylus semicircular; fingers with small teeth proximally on cutting edges; merus ventrally spinulate.
7. Telson with small marginal dorsal spines on posterior half.	Telson with large submarginal dorsal spines on anterior half.

Points of particular taxonomic importance which are found in both *T. australis* and *T. tortugae* are listed below:

1. Rostrum short, compressed, toothless.
2. Large acute "para-orbital" spines absent.
3. Incisor process of mandible well developed.
4. Exopods of maxilliped well developed.
5. Chela of second pereiopods similar and only slightly unequal.
6. Dactyls of ambulatory pereiopods slender with feeble accessory spines.
7. Exopod of uropod with entire lateral border.

Typton australis may be easily separated from the two Indo-West-Pacific species. It may be easily distinguished from *T. dentatus* Fujino and Miyake (1969), by the absence of a dorsally dentate rostrum and antennal spines, and from the new species of *Typton* (Bruce, in press, b) from the Indian Ocean by the absence of an inferior orbital angle, the presence of a large acute tooth on the fixed fingers of the second pereiopod, the slender propods, and the absence of spinulation along the ventral borders of the dactyls of the ambulatory pereiopods. From these species *T. australis* differs noticeably in the relative size of the scaphocerite, which is reduced to a very small rudiment in both, considerably smaller in size than is found in *T. australis*.

DISCUSSION

The genus Typton, was established by Costa (1884) for the Mediterranean species *T. spongicola*, which has been subsequently found along the eastern Atlantic coasts of Europe and Africa (Holthuis, 1951a). More recently a further seven species from central American waters have now been placed in the same genus (Holthuis, 1951b). Prior to 1969 the genus appeared to be absent from the Indo-West Pacific region, of which the shallow water pontoniinid fauna appeared to be relatively well known, and included numerous sponge associated species with which *Typton* might have been expected to occur. The first species to be discovered in the Indo-West

Pacific region was *T. dentatus* reported from the Ryukyu Islands by Fujino and Miyake (1969) and subsequently a new species has been found in the western Indian Ocean (Bruce, in press, b). It is unfortunate that both these species are incompletely known, as the second pereiopods were partly or completely lacking from the few specimens known.

In the reports upon *T. dentatus* and the new Indian Ocean species, it was found necessary to modify the description of the genus given by Holthuis (1951a) and the discovery of *T. australis* appears to render further modification necessary. The latter species presents some characteristics showing an affinity to the genus *Onycocaris* Nobili, also found in association with sponges. Three features are particularly important in this context.

1. *The scaphocerite.* In *T. australis* this appendage is much less reduced than in any other species of *Typton.* This reduction of the scaphocerite is the main diagnostic character (Holthuis, 1952), used to separate *Typton* from all other pontoniinid genera, other than the unrelated genus *Paratypton* Balss (Bruce, 1969). In most genera, the scaphocerite far out-reaches the carpocerite. In the genus, *Onycocaris,* several species show reduction of the scaphocerite so that the lamina is distinctly exceeded by the carpocerite, for example *O. spinosa* and *O. quadratophthalma,* (Fujino and Miyake, 1969). In *T. australis* the lamina of the scaphocerite reaches a little beyond the middle of the carpocerite and is therefore intermediate between the two genera.

2. *The chelae of the second pereiopods.* In his definition of the genus *Typton,* Holthuis (1951a) states that the second legs are very heavy and unequal. This is certainly true of most species but, as noted above, the characteristic is not particularly well marked in *T. tortugae.* The condition in the two Indo-West Pacific species *T. dentatus* and *T. bawii* is uncertain in as much as the chelae are completely unknown in the former and only one, probably the smaller, is known in the latter. It cannot be said therefore that the chelae are very heavy and unequal in the Indo-West Pacific species. In *T. australis,* where both second pereiopods have fortunately been preserved, the chelae are small, similar and only slightly unequal. In addition, the palm of the chela, although swollen, is noted to be slightly compressed. In most species of *Onycocaris* the chelae of the pereiopods are similar and of subequal size. In most species the palm is distinctly compressed, for example, in *O. quadratophthalma* Balss, but in some, such as *O. stenolepis* Holthuis and *O. monodoa* Fujino and Miyake, this is not particularly marked. In this respect also, *Typton australis* appears as an intermediate stage between *Typton* and *Onycocaris.*

3. *Carapace spines.* In most species of the genus *Typton* a large "paraorbital" spine is present forming the lateral limit of the orbit. These spines do not appear to be homologous with the inferior orbital angle or the antennal spines found in other pontoniinid shrimps (Holthuis, 1951a; Bruce, in press, b). In *Onycocaris* the inferior orbital angle may be acutely produced, as in *O. monodoa* or broadly rounded and blunt as in *O. spinosa. Typton australis* shows considerable similarity to the latter species in the form of the anterior margin of the carapace in which the inferior orbital angle is obsolescent and the antennal spine absent. In all three Indo-West Pacific species, the conspicuous "paraorbital" spines found in the other members of the genus (with the exception of *T. tortugae*), are absent. In *T. dentatus* the antennal spine is stated to be distinct. It is small and situated at the inferior orbital angle and is slender and acute. It shows considerable resemblance to the antennal spine of *O. monodoa* and is probably more correctly considered to be the inferior orbital angle. In the new Indian Ocean species, the inferior orbital angle is produced and broadly angular. In this respect again, *T. australis* represents a link between the genera *Typton* and *Onycocaris.*

Most of the morphological features that have been noted as characteristic of *T. australis* are of a negative nature. The scaphocerite is not so reduced as in other *Typton* species, there are no "paraorbital" spines, the chelae of the second pereiopods are not large and unequal as in *Typton* or subequal and compressed as in *Onycocaris*. In other words, *T. australis* lacks many of the specializations that have been developed in the other species of *Typton* and *Onycocaris*. In this sense it is primitive and may be closely related to the ancestral stock of both genera.

If the present specimen is correctly referred to the genus *Typton*, we must modify further the redefinition of the genus that was recently given (Bruce, in press, b). This course appears preferable to the erection of a poorly defined monospecific genus, intermediate between *Typton* and *Onycocaris*. Further information on important features of the two other Indo-West Pacific species, such as the morphology of the chelae of the second pereiopods, may indicate that the three species do form a natural unit, distinct from those from other regions. Until such further information becomes available, this specimen is placed in a definition of the genus *Typton* modified to include species with or without "paraorbital" spines, with the inferior orbital angle produced or obsolescent, with second pereiopods large, unequal and dissimilar or small, similar and subequal.

The ova in *T. australis* are unusually large and few in number. In general the longer axes of the ova of pontoniinid shrimps are about 0.5 mm, although some small species have much smaller ova. The ova of *T. australis* are unusually large for the size of the shrimp. Their size (0.63 mm) however, is comparable to that of *T. spongicola* Costa which is given by Lebour (1925) as 0.5–0.8 mm, and is well below the size found in *Pontonia minuta* Baker (1.3–1.5 mm), in which abbreviation of the series of larval stages occurs (Bruce, in press).

Although the host was not identified, it is most probable that *T. australis*, like other species of the genus *Typton*, lives in association with sponges.

ACKNOWLEDGMENT

I am most grateful to Dr D. J. G. Griffin for the opportunity to report upon this specimen.

REFERENCES

Bruce, A. J., 1969. Notes on some Indo-Pacific Pontoniinae. XIV. Observations on *Paratypton siebenrocki* Balss. *Crustaceana* 17: 171–186, figs 1–5, pl. 1.

——— in press, a. Notes on some Indo-Pacific Pontoniinae XVIII. A re-description of *Pontonia minuta* Baker, 1907 and the occurrence of abbreviated development in the Pontoniinae. *Crustaceana.*

——— in press, b. The first occurrence of the genus *Typton Costa*, in the Indian Ocean *Crustaceana.*

Costa, O. G., 1884. Su due nuovi generi di Crostacei Decapodi Macruri nota. *Ann. Acad. Aspir. nat. Napoli,* 2: 285.

Fujino, T. and Miyake, S., 1961. *Typton dentatus* sp. nov., from the Ryukyu Islands, Japan with discussion on the generic characters. *Ohmu* 2: 79–86, figs 1–2.

——— 1969. Studies on the genus *Onycocaris* with descriptions of five new species (Crustacea, Decapoda, Palaemonidae). *J. Fac. Agric., Kyushu Univ.* 15: 403–448, figs 1–18.

Holthuis, L. B., 1951a. The caridean Crustacea of Tropical West Africa. *Atlantide Rep.* 2 1951: 7–187, figs. 1–34.

——— 1951b. A general revision of the Palaemonidae (Crustacea Decapoda Natantia) of the Americas. I. The sub-family Euryrhynchinae and Pontoniinae. *Occ. Pap. Hancock Found.* (11): 1–332, pls 1–63.

——— 1952. The Decapoda of the Siboga Expedition. II. The Palaemonidae, 2. Sub-family Pontoniinae. *Siboga Exped. Monogr.*, 39a10: 1–254, figs 1–110, tab. 1.

Lebour, M. V., 1925. The eggs and newly hatched larva of *Typton spongicola* O. G Costa. *J. mar. biol. Ass. U.K.* 13: 848–853, figs 1–3.

A New Species of *Notuchus* (Homoptera, Fulgoroidea, Delphacidae) from Lord Howe Island

NATIONAL MU
22 JAN 19
OF VICTOR

By R. G. Fennah
Commonwealth Institute of Entomology, London

Figures 1–9

Manuscript received 17th March, 1972

Through the kindness of Dr J. W. Evans, I have been able to examine a male Delphacid taken in moss at the summit of Mt Gower, Lord Howe Island. This has proved to represent a new species of the Asiracine genus *Notuchus*, and is described below. It has become evident during this study that some of the features originally used to define the genus are of no more than specific value, and the opportunity is taken to provide a revised definition.

Notuchus Fennah

Fennah, 1969: 32; type species, *Notuchus risioides* Fennah, 1969.

Form ovate, depressed, nearly twice as long as broad. Bodily length about 4.5 mm. Vertex broader than long, anterior margin distinctly convex, posterior margin transverse, disc medially carinate in basal half. Frons slightly longer than broad, widest in distal third, a pair of sublateral carinae closely approximated to lateral margins, and sometimes uniting with them and a pair of well-defined arcuate submedian carinae; median carina absent; clypeus tricarinate; rostrum long, much surpassing post-trochanters; ocelli absent, genae narrow; antennae attaining level of middle of clypeus with segments subequal, basal segment sub-cylindrical, slightly flattened dorsally. Pronotum with anterior margin between eyes transverse or shallowly convex, posterior margin shallowly concave, lateral lobes extending laterad almost horizontally, disc tricarinate, lateral carinae concave, almost attaining posterior margin, a small impression in each compartment of median disc, and a more prominent impression near mesal edge of each lateral lobe; mesonotum about twice as broad as long, tricarinate; tegmina brachypterous, about as broad as long, shallowly convex, coriaceous, costal margin in basal half inflected mesad, apical margin transverse or nearly so, venation coarse, more or less densely reticulate; wings absent; femora and tibiae of fore and middle legs a little compressed, post tibiae each laterally trispinose and with four or five spines apically, spur subulate, moderately long; basal metatarsal segment half as long as post-tibia, with four teeth at apical margin and a further tooth basad of the remainder; second metatarsal segment with three teeth apically; abdomen depressed, terga medially carinate and with two or four supernumerary carinae, ninth tergum of male roofed over by eighth tergum. Anal segment of male short, collar-like. Pygofer rather short.

The most distinctive features of the genus are the double lateral margins of the frons, the subhorizontal carriage of the lateral lobes of the pronotum and the presence of an impression on each lobe. The dentition of the hind legs indicates that *Notuchus* belongs to the group of Asiracine genera headed by *Ugyops*, and it is fortunate, for

Rec. Aust. Mus., **28**, page 265.

purposes of comparison, that truly brachypterous species of *Ugyops* exist. These include *U. pelorus* Fennah from New Zealand and *U. raouli* from the Kermadec Is. and serve to show what morphological changes occur in *Ugyops* as an accompaniment to brachyptery and that they do not significantly narrow the gap between the two genera.

Notuchus monticola sp. n.

Figs 1–9

Description.—Male. Vertex broader at widest part (just before eyes) than long in middle line (1 : 1.25), strongly produced before eyes, anterior margin deeply subacutely convex, confluent with lateral margins and slightly elevated, posterior margin transverse, disc shallowly impressed medially in distal half, a broad median carina weakly present in basal half; frons slightly longer in middle line than broad (1.1 : 1), widest at about four-fifths from base, submedian carinae replacing lateral margins in basal fifth, lateral margins each formed of two narrowly separated fine ridges (representing the sublateral carinae and the true lateral margins) on each side from level of lower margin of eyes to widest part of frons, median carina absent, median disc of frons finely rugulose, submedian carinae each nearer to lateral margin than to middle line of frons; antennae with basal segment longer than broad at apex (about 2.4 : 1), subcylindrical, very slightly flattened on upper surface, second segment as long as first, slightly expanding distad; tegmina about as long as broad, subquadrate, not covering fourth abdominal tergum, apical and anal angles broadly rounded, venation irregular, densely reticulate, no longitudinal veins or claval suture discernible.

Antennae, vertex, pronotum, mesonotum and abdominal terga, except for six small piceous spots on each tergum, orange brown; frons, except for five round pale spots near each lateral margin, clypeus, except for a tawny spot on each side distally, genae below antennae, pleura, coxae at base and apex, femora distally, and abdomen ventrally except for lateral margins and an ovate spot near each lateral margin, and pygofer except in posterior half of ventral surface, dark reddish brown; tegmina dull yellowish-brown.

Anal segment of male about as broad as long, deep, collar-like. Pygofer rather short, lateral margins a little produced in an acute angle, ventral margin produced caudad at middle in a broad, shallow subquadrate lobe. Genital styles in ventral view of genitalia narrow, slightly widening distad, strongly curved mesad in basal third, weakly incurved in distal two-thirds and meeting in middle line apically.

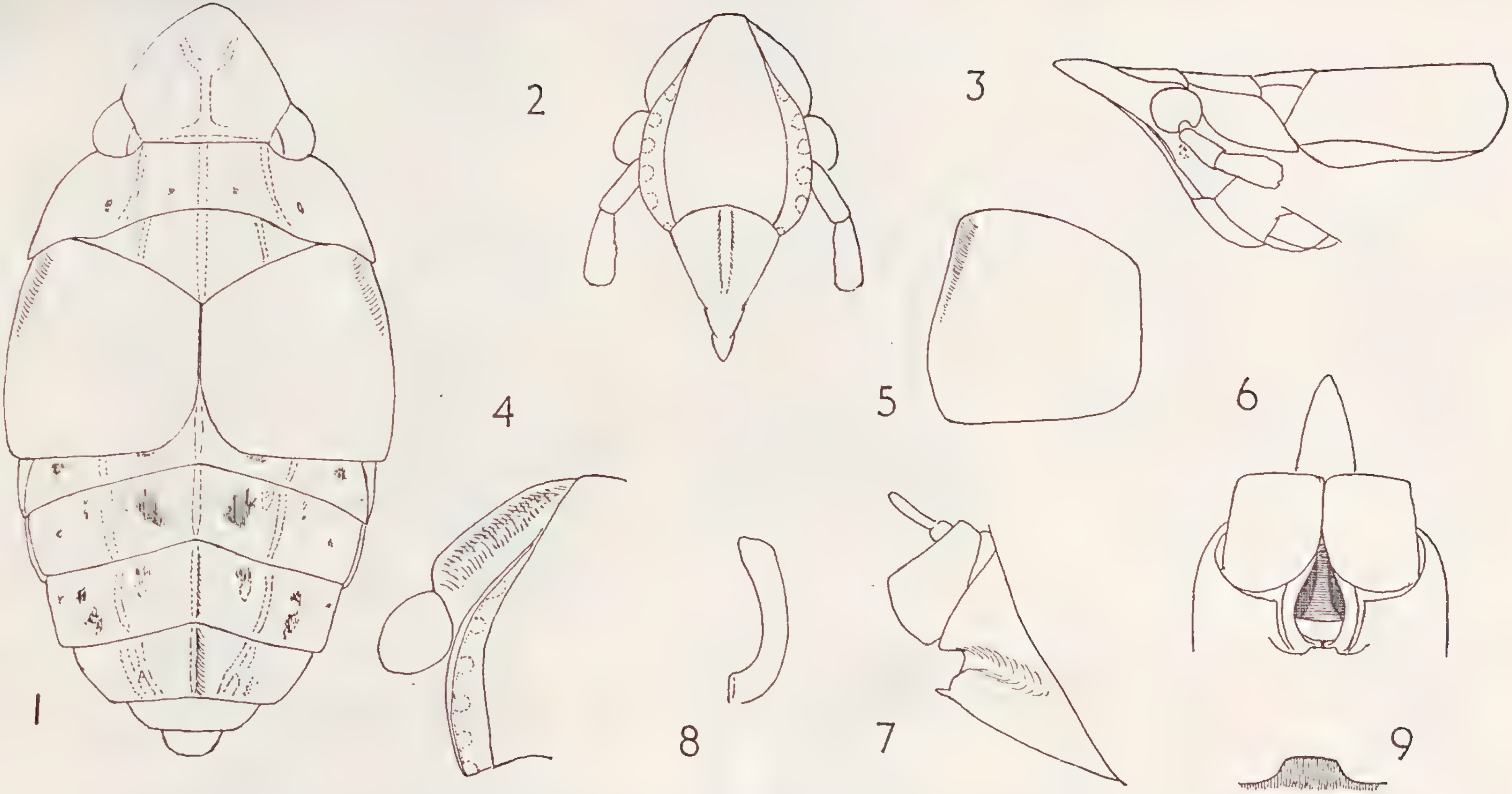
Type material.—Holotype male, length 4.5 mm; tegmen, 1.3 mm. Summit of Mt Gower, Lord Howe Island, in moss, July 1971, coll. J. Disney, in Australian Museum.

Remarks.—This species differs from *N. risioides* in the shape and carination of the vertex and frons, the shape and venational pattern of the tegmina, the presence of a medioventral process on the pygofer, and the shape of the genital styles.

The discovery of this species establishes a link, hitherto unsuspected, between the fulgoroid faunas of Lord Howe Island and New Caledonia. It will clearly be of interest to ascertain whether a native species of *Notuchus* or one of *Ugyops* occurs on Norfolk Island.

REFERENCE

Fennah, R. G., 1969. Fulgoroidea (Homoptera) from New Caledonia and The Loyalty Islands. *Pacif. Ins. Monogr.*, 21: 1–116.



Figs 1–9. *Notuchus monticola* n. sp.—1, dorsal view of body; 2, frons and clypeus; 3, head, pronotum, mesonotum and tegmen, left side; 4, margin of frons, right side, anterolateral view, showing the two narrowly-separate carinae at margin not quite uniting at their dorsal extremity with right submedian carina; 5, tegmen; 6, male genitalia, posteroventral view; 7, the same, right side; 8, right genital style, posteroventral view; 9, medioventral process of pygofer, ventral view, with portions of narrowly infuscate posterior margin.

GALATHEIDEA (CRUSTACEA, DECAPODA, ANOMURA) COLLECTED BY THE F.I.S. *ENDEAVOUR*

NATIONAL MUSEUM
22 JAN 1973
OF VICTORIA

By JANET HAIG

Allan Hancock Foundation, University of Southern California, Los Angeles, California, U.S.A.

Figures 1 and 2. Manuscript received, 20th March, 1972

ABSTRACT

Eleven species of Galatheidae and five of Porcellanidae are reported from the collections of the *Endeavour* off the Australian coast. *Munida elegantissima* De Man, *M. japonica* Stimpson, *M. microps* Alcock, and *Galathea balssi* Miyake and Baba are reported from Australia for the first time, and the latter two species are illustrated. *Galathea whiteleggii* Grant and McCulloch, an Australian species not collected by the *Endeavour*, is illustrated and compared with the closely related *G. balssi*. Earlier Australian records of the other 12 *Endeavour* species are cited, and range extensions are established for eight of them. Keys to the known Australian species of *Munida* and eastern Australian species of *Galathea* are presented.

INTRODUCTION

While operating off the coast of Australia from 1909 to 1914, the Fisheries Investigation ship *Endeavour* collected a number of anomuran crustaceans of the superfamily Galatheidea. Most of this material was deposited in the Australian Museum. During a visit of several days to the Museum in 1968 I examined a portion of it, and Dr J. C. Yaldwyn, then Curator of Crustacea, arranged for the rest to be sent to the Allan Hancock Foundation for study. Earlier I had received a small series of *Endeavour* specimens from the Western Australian Museum.

In a report on macruran Crustacea collected by the *Endeavour*, Schmitt (1926: 311) indicated that he planned to treat the Anomura as well. However, no paper on any of the anomuran groups was ever published; several families of decapods from the *Endeavour* collection were sent to Dr Schmitt at the Smithsonian Institution but remained unworked and were eventually returned to the Australian Museum (Dr R. B. Manning, personal communication). It is probable, therefore, that the material reported upon in this paper represents all the Galatheidea that were collected and preserved during the vessel's fisheries investigations.

Rec. Aust. Mus., **28**, page 269.
40782-A

No Chirostylidae are represented, although some members of that family are known to occur within the geographic and bathymetric limits of the *Endeavour's* collecting activities. The collection is rather small, containing only 11 species in the family Galatheidae and five in the family Porcellanidae. However, four species of galatheids are new to Australian waters, and several species in both families were found to occur outside their previously known ranges in Australia. A few additional range extensions are noted herein.

Most of the *Endeavour* collecting localities mentioned in the text are shown on the map accompanying Schmitt's paper (Schmitt, 1926: 314–315).

The present report is one of a series of studies on Australian anomurans. Some of the species will be treated subsequently and are only briefly discussed here. A few others, which I do not anticipate reporting upon again, are given more detailed treatment. I have also taken this opportunity to include a key to the species of *Munida* now known from Australia and a key to the species of *Galathea* known from eastern Australia.

Measurements given in this paper refer to carapace length including the rostrum, unless there is a statement to the contrary. Synonymies are not intended to be complete, but for each species I have included a reference to its original description and those of its junior synonyms, and all references I have been able to find that cite its occurrence in Australian waters. I have also included references to certain other papers containing pertinent information. Samples belonging to the Western Australian Museum are identified by the initials W.A.M. before the register number; all others are part of the collections of the Australian Museum.

SYSTEMATIC ACCOUNT

Family **GALATHEIDAE**

Munida Leach, 1820

Munida elegantissima De Man, 1902

Munida elegantissima De Man, 1902: 726, pl. 24 figs 42, 42 a, b.—Tirmizi, 1966: 190, text-fig. 12.—Baba, 1969b: 37, text-figs 3, 4.

Munida alcocki Southwell, 1906: 222, text-fig. 2.

Diagnosis.—Carapace strongly rugose; anterior margin nearly transverse, with a small supra-antennal spine. Lateral spines well developed, anterolateral somewhat larger than the others. A transverse row of ten subequal anterior gastric spines; a spine near each end of the first transverse stria, one or two on each anterior branchial area, and two on the first postcervical stria. Supraocular spines more than half length of rostrum. Corneas only slightly broader than eyestalks. Abdominal segments unarmed. Outer terminal spine of basal antennular segment much longer than inner terminal spine. Pereiopods 1–3 with an epipod.

Material.—Between Fremantle and Geraldton, Western Australia; 1912; 1 ♀, W.A.M 4983.

Measurements.—Ovigerous female 14.0 mm.

Distribution.—I have examined material from several additional localities in Western Australia; also a specimen from NE of Cape Moreton, Queensland, 60–70 fathoms, which was sent for identification by Dr A. J. Bruce and is now in the collections of the Allan Hancock Foundation. These records are the first for the species in Australian waters. It is otherwise known from east Africa off Zanzibar; Amirantes and Providence Island; Gulf of Mannar between India and Ceylon; East Indian Archipelago; and Japan. The bathymetric range is shallow water to 78 fathoms (142 metres).

Munida japonica Stimpson, 1858

Munida japonica Stimpson, 1858: 238, 252; 1907: 235.—Balss, 1913: 15, text-fig. 14.—Melin, 1939: 85, text-figs 54–57.—Tirmizi, 1966: 190, 195, text-figs 15, 16.—Miyake and Baba, 1967: 240, text-figs 11, 12.—Lewinsohn, 1969: 131, text-fig. 26.

Munida honshuensis Benedict, 1902: 251, 261, text-fig. 11.

Munida japonica japonica.—Yanagita, 1943: 14, 24, text-fig. 7.

Diagnosis.—Carapace distinctly rugose; anterior margin oblique, unarmed. Lateral spines well developed, anterolateral somewhat larger than the others. A transverse row of 10–13 anterior gastric spines, pair just behind supraoculars the largest; a spine near each end of the first transverse stria, and two on the first postcervical stria. Supraocular spines half or less than half length of rostrum. Breadth of corneas variable. Second abdominal segment usually armed with about eight to ten spines, none occurring near midline. Outer and inner terminal spines of basal antennular segment about the same length. Epipod wanting on all pereiopods.

Material.—Between Fremantle and Geraldton, Western Australia; 80–120 fms; 1912; 3 ♂, 4 ♀, W.A.M. 4982.

Measurements.—Males 10.9 to 13.3 mm, ovigerous females 10.2 to 11.7 mm.

Remarks.—Several writers have commented on the great intra-specific variation that is characteristic of *Munida japonica*. I have examined a number of Western Australian specimens, which will be discussed elsewhere; these agree very closely with one another and do not show marked differences in width of the eyes, spinulation of the carapace and abdomen, relative length of the supraocular spines, and other variable characters.

Distribution.—Munida japonica is now reported from Australia for the first time. It ranges from the Red Sea eastward to Japan, East Indian Archipelago, and Bismarck Archipelago, to depths of at least 500 metres.

Munida microps Alcock, 1894

Fig. 1

Munida microps Alcock, 1894: 326; 1901: 238, 240.—Alcock and Anderson, 1895: pl. 13 fig. 5.—Tirmizi, 1966: 190, 194, text-fig. 14.

Diagnosis.—Carapace strongly rugose, areas well defined; anterior margin oblique, unarmed. Anterolateral and second hepatic spines much stronger than other lateral spines. Anterior gastric area with three or four pairs of spines, inner (first) pair very

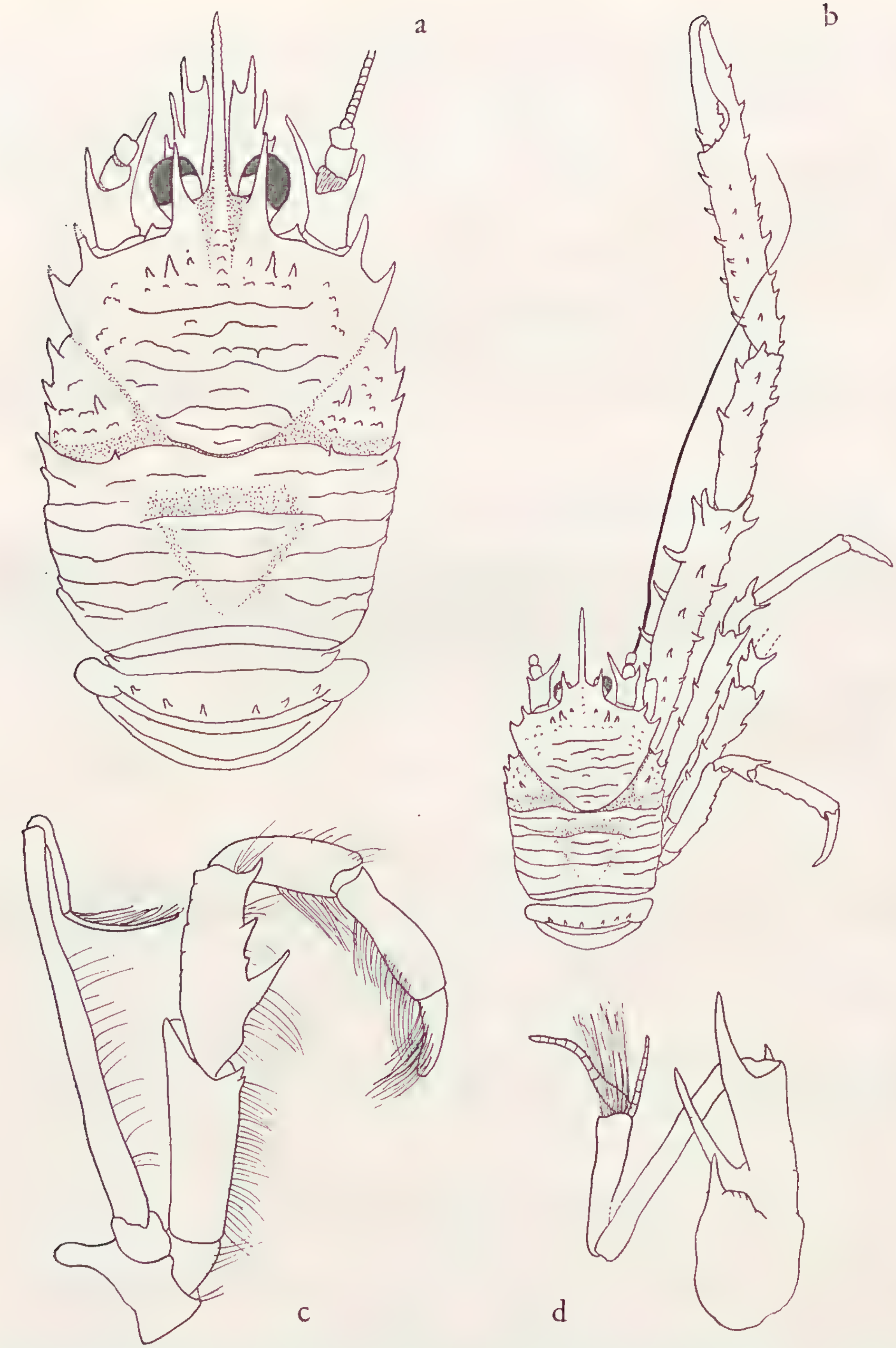


Figure 1.—*Munida microps* Alcock, male. Off Green Cape, New South Wales, E.3142. a, carapace, x3½; b, carapace and pereiopods, x1½; c, right third maxilliped, ventral view, x7; d, right antennule, ventral view, x7

small, second pair distinctly larger than the others; spinules or sharp granules often present, several on hepatic area and one near each end of the first transverse stria; one or two spines on each anterior branchial area and two on the first postcervical stria. Supraocular spines less than half length of rostrum. Eyes small; corneas scarcely broader than stalks, at least in adults. Second abdominal segment with six to ten spines. Outer terminal spine of basal antennular segment much longer than inner terminal spine. Epipod wanting on all pereiopods.

Material.—33 miles E by S from Green Cape, New South Wales; 470 fms; 1912; 1 ♂, 1 ♀, E.3142.

Measurements.—Male 24.3 mm, ovigerous female 11.7 mm.

Remarks.—In the small female specimen the second hepatic spine is smaller than the anterolateral; the supraocular spines are slightly longer in relation to the rostrum than in the male; the keel extending from the rostrum to the first transverse stria is spinulose posteriorly instead of scaly; the corneas are slightly broader than the eyestalks; and the spines on the first movable segment of the antennal peduncle are shorter than in the figured specimen, the inner one not extending beyond the end of the second segment.

Alcock (1894: 327) recognized a variety *lasiocheles*, based on two male specimens, in which the chelipeds are much longer than in typical *microps* and one cheliped is markedly longer than the other. In a later paper (1901: 242) he considered these specimens to be merely dimorphic males of *M. microps*. However, in the illustration of this form under the name *Munida lasiocheles* (Alcock and Anderson, 1895: pl. 13 fig. 8) the rostral, supraocular, and gastric spines are quite unlike those of typical *microps*; if they are accurately depicted, Alcock's "variety" is probably a distinct species.

Distribution.—This species was previously reported from the Andaman and Arabian Seas in the Indian Ocean, in 375 to 675 fathoms (686 to 1,234 metres). Its known range is now extended to southeastern Australia.

Munida haswelli Henderson, 1885

Munida haswelli Henderson, 1885: 411; 1888: 139, pl. 3 figs 5, 5 a, b.—Whitelegge, 1900: 193.—Hale, 1927a: 80, text-fig. 76; 1941: 273.

Diagnosis.—Carapace distinctly rugose, the striae numerous; anterior margin oblique, unarmed. Anterolateral spine well developed, other laterals small. Anterior gastric area with a pair of large spines behind supraoculars, and another pair directly behind these on the first transverse stria; numerous spines or spinules on anterior gastric and hepatic areas, one or two spines (occasionally more) on each anterior branchial area, and two spines on the first postcervical stria. Supraocular spines about half length of rostrum. Corneas much broader than eyestalks. Second abdominal segment usually with six to ten spines, third segment sometimes with two or three. Inner terminal spine of basal antennular segment much longer than outer terminal spine. Epipod wanting on all pereiopods.

Material.—Off Gabo I., Victoria; 80–100 fms; 1913; 1 ♂, E.4781.—S and SW of Mt Cann, Gippsland, Victoria; 70–100 fms; 2 ♂, 5 ♀, 2 juv., E.6114.—40 miles SSW of Mt Cann; 70 fms; 27 August 1914; 3 ♂, 2 ♀, E.6276.—ENE of Maria I., Tasmania; 127–180 fms; 1914; 2 ♂, 6 ♀, E.5175.—35 miles SE of Bruny I., D'Entrecasteaux Channel, Tasmania; 150–230 fms; 1914; 2 ♀, E.5154.—Great

Australian Bight ESE of Eucla, Western Australia, 130° 50′ E; 1913; 1 ♂, E.3688.—Great Australian Bight 60–80 miles W from Eucla; 80–120 fms; March, 1912; 4 ♂, 1 ♀, 6 juv., E.3172, and 2 ♂, 7 ♀, 4 juv., P.3555.

Measurements.—Males 9.0 to 31.3 mm, non-ovigerous females 10.2 to 34.0 mm, ovigerous females 8.0 to 13.2 mm.

Distribution.—New South Wales off Twofold Bay (Henderson, 1885, 1888) and off Botany Bay and Wollongong (Whitelegge, 1900); off Maria Island, Tasmania (Hale, 1941); off coast of South Australia (Hale, 1927a). The bathymetric range is reported as 50 to 150 fathoms (about 90 to 270 metres). The material collected by the *Endeavour* extends the known geographic range westward to Western Australia and the bathymetric range downward to 230 fathoms (420 metres).

Munida subrugosa Dana, 1852

Galathea subrugosa White, 1847: 66 (nomen nudum).—Miers, 1874: pl. 3 fig. 2.

Munida subrugosa Dana, 1852: 479; 1855: pl. 30 figs 7 a-c.—Miers, 1874: 3.—Filhol, 1885: 425.—Sayce, 1902: 155.—Lagerberg, 1905: 7, 10, pl. 1 figs 5, 7.—Matthews, 1932: 473 *et seq.*, pl. 4 figs 1, 4, text-figs 1 a-f.—Healy and Yaldwyn, 1970: 68, fig. 33.

Munida subrugosa, var. *australiensis* Henderson, 1888: 125, pl. 13 figs 3, 3 a, b.—Ortmann, 1892: 254.

Munida australiensis.—Benedict, 1902: 306.

Diagnosis.—Carapace strongly rugose; anterior margin oblique, unarmed. Anterolateral spine well developed, other laterals small. Anterior gastric area with a pair of large spines and usually two to four spinules; sometimes a small spine near each end of the first transverse stria, a pair on the posterior part of the gastric area, and one on each anterior branchial area; first postcervical stria with four spines. Supraocular spines variable in length but shorter than rostrum. Corneas much broader than eyestalks. Second abdominal segment with four spines, third segment with two to four, fourth segment with two on anterior margin and rarely a smaller pair posteriorly. Inner terminal spine of basal antennular segment much longer than outer terminal spine. Epipod wanting on all pereiopods.

Material.—40 miles SSW of Mt Cann, Victoria; 70 fms; 27 August 1914; 1 ♂, P.17560.—E coast Flinders I., Bass Strait; 17 May 1909; 1 ♂, 5 ♀ (part of a large series), E.1057.—E coast Flinders I.; 1909; 2 ♂, 4 ♀ (part of a large series), P.2330.—Entrance to Oyster Bay, Tasmania; 30 July 1909; 3 ♂, 11 ♀, E.5682.—Maria I., Tasmania; 7 October 1910; 11 ♂, E.1341.

Measurements.—Males 11.5 to 25.4 mm, non-ovigerous females 17.1 to 19.5 mm, ovigerous females 11.0 to 18.9 mm.

Distribution.—This species was previously reported from Australia at Port Phillip, Victoria (Sayce, 1902) and in Bass Strait (Filhol, 1885; Henderson, 1888; Ortmann, 1892; Healy and Yaldwyn, 1970) to a maximum depth of 40 fathoms (72 metres). The known geographic range is now extended southward to Maria Island off the Tasmanian coast, and the bathymetric range in Australian waters is extended to 70 fathoms (126 metres).

Munida subrugosa is also known from New Zealand and its subantarctic islands, the southern part of South America (where it extends as far north as 50° S. Lat. on the west coast and 35° S. Lat. on the east coast), and Falkland Islands. The greatest depth recorded for the species is 600 fathoms (1,097 metres).

Key to Species of Munida known from Australia

1 Terminal spines of basal antennular segment about the same length, or outer spine much the longer 2

— Inner terminal spine of basal antennular segment much longer than outer terminal spine 5

2 (1) A row of six to eight anterior gastric spines; second lateral spine about as large as anterolateral .... *M. microps*

— A row of 10–13 anterior gastric spines; second lateral spine smaller than anterolateral 3

3 (2) A small spine on anterior margin of carapace; pereiopods 1–3 with an epipod .... *M. elegantissima*

— Anterior margin of carapace unarmed; epipod wanting on all pereiopods.... 4

4 (3) Abdominal segments 2 and 3 each with a single median transverse groove, segments 4–6 smooth (in Australian specimens); two or three lateral spines in anterior branchial area .... *M. japonica*

— Abdominal segments 2–6 each with several transverse grooves; four lateral spines in anterior branchial area .... *M. spinulifera* (Miers, 1884: 279, pl. 31 fig. A, not fig. B as stated).

5 (1) A pair of well-developed spines just behind large anterior gastric pair; abdominal segment 2 with six to ten spines, segment 4 unarmed .... *M. haswelli*

— No spines just behind large anterior gastric pair; abdominal segment 2 with four spines, segment 4 with two spines .... *M. subrugosa*

Allogalathea Baba, 1969

Allogalathea elegans (White, 1848)

Galathea elegans White, 1847: 66 (nomen nudum).—White in Adams and White, 1848: pl. 12 fig. 7.—Miers, 1884: 278.—Grant and McCulloch, 1906: 43, 50, pl. 4 figs 6, 6a.—Potts, 1915: 83, pl. 1 fig. 5, text-fig. 4A.—Balss, 1921: 22.—Miyake and Baba, 1967: 228, text-fig. 3.—McNeill, 1968: 33.—Gillett, 1968: 15.—Lewinsohn, 1969: 123, text-fig. 24.—Healy and Yaldwyn, 1970: 68, pl. 31.

?*Galathea longirostris* Dana, 1852: 482; 1855; pl. 30 fig. 11.

?*Galathea grandirostris* Stimpson, 1858: 238, 252; 1907: 234.

Galathea deflexifrons Haswell, 1882a: 761; 1882b: 163.

Galathea elegans?.—Haswell, 1882b: 163.

Galathea longirostris Yokoya, 1936: 138, text-fig. 6.

Allogalathea elegans.—Baba, 1969a: 6, text-fig. 1.

Diagnosis.—Anterior half of carapace with several uninterrupted transverse striae; dorsal surface unarmed. Rostrum very long and narrow, with five to nine small teeth on each lateral margin. Abdominal segments 2 and 3 with two transverse grooves, the more anterior one sometimes indistinct. Terminal segment of antennular peduncle without a pronounced tuft of hairs. Merus of third maxillipeds with two or three strong spines on inner margin; outer margin unarmed or with one or two spinules. First pair of pereiopods with an epipod.

Material.—25 miles SE from Double Island Point, Queensland; 33 fms; 1913; 1 ♂, E.4512.

Measurements.—Length of carapace including rostrum 9.5 mm; length of chelipeds 22.3 mm.

Remarks.—The highly variable colour pattern of this species has been mentioned by many writers. Most of the colour has faded on the specimen collected by the *Endeavour*, but it appears to have had three narrow, longitudinal dark stripes, one median and two sublateral, on the carapace and abdomen.

Baba (1969a: 6) noted that the type of *Galathea elegans* White, from the Philippine Islands, has an epipod on the first pereiopods only, as confirmed by Drs Isabella Gordon and R. W. Ingle at the British Museum (Natural History). Baba found the same situation to exist in all the Japanese specimens examined by him; but he mentioned material from the Palau Islands in which an epipod is present on the second and third pereiopods as well. Since the number of epipods is constant within a given species, it appears that there are two forms confused under the name *elegans*. Baba suggested that the nominal species *Galathea longirostris* Dana (type-locality Fiji Islands), *G. grandirostris* Stimpson (type-locality Kagosima Bay, Japan), and *G. deflexifrons* Haswell (type-locality Albany Passage, Queensland), as well as a number of records of *G. elegans*, should be removed from the synonymy of White's species until the number of epipods can be determined by re-examination of material on which these records were based. Baba retained *G. longirostris* Yokoya (a junior homonym of *G. longirostris* Dana) as a synonym of *elegans*, so presumably he was able to examine Yokoya's type-material.

The question can probably never be settled for *Galathea longirostris* Dana and *G. grandirostris* Stimpson, for the types of those species are almost certainly lost. The holotype of *G. deflexifrons* Haswell is in the Australian Museum (P.3885), but it is unfortunately dry and could not be examined for epipods without damaging the specimen. However, I think there can be little doubt that it is a synonym of *Allogalathea elegans* and that all the Australian records belong to that species. I have examined many specimens from Queensland and from Western Australia and in all of them there is an epipod on the chelipeds only. Until evidence is introduced to the contrary, it seems best to assume that the form with an epipod on the second and third pereiopods does not occur in Australia.

Distribution.—*Allogalathea elegans* has been reported from off Cape Jaubert, Western Australia (Balss, 1921) and in Queensland from Torres Strait south to Port Curtis (Haswell, 1882a, 1882b; Miers, 1884; Grant and McCulloch, 1906; Potts, 1915; McNeill, 1968; Gillett, 1968; Healy and Yaldwyn, 1970). The known range is now extended southward in Queensland.

The species is reported from the Red Sea and east coast of Africa eastward to the Fiji Islands but, as noted above, some of the published records need confirmation. It is recorded from the littoral to 80 fathoms (146 metres), frequently in association with comatulid Crinoidea.

Galathea Fabricius, 1793

Remarks.—The best source of information on *Galathea* from the east coast of Australia is the review by Grant and McCulloch (1906: 43–52). Their key, until now the only one available for identification of Australian members of the genus, is very much out of date. *G. elegans* and *G. pusilla* have been removed from *Galathea* and placed by Baba (1969) in *Allogalathea* and *Phylladiorhynchus*, respectively; *G. corallicola*, which Grant and McCulloch considered a synonym of *G. australiensis*, has proved to be a distinct species; and four additional forms have been reported from Queensland since publication of their paper. A new key to the species of *Galathea* from eastern Australia, reflecting these changes, is given in the present report. It includes the nine species now known to occur along the east coast of the continent, but this number will undoubtedly be increased when the Galatheidae of the area are studied in more detail. The key should not be used to identify *Galathea* from tropical Western Australia, where the composition of the genus is quite different. Western Australian members of the genus are now under study and will be treated elsewhere.

Members of the genus *Galathea* (as restricted by Baba, 1969a) are described by some writers as having four teeth on each lateral margin of the rostrum. Other writers, who consider the most proximal of these teeth to be supraocular rather than rostral, state that the number of rostral teeth is three on each side. I concur with the latter point of view, and therefore refer to three pairs of rostral teeth throughout the following discussion.

Galathea australiensis Stimpson, 1858

Galathea australiensis Stimpson, 1858: 238, 251; 1907: 230.—Haswell, 1882b: 161.—Miers, 1884: 277 (in part), pl. 31 fig. B (not fig. A as stated).—Whitelegge, 1900: 189.—Sayce, 1902: 155.—Grant and McCulloch, 1906: 43, 44 (in part), pl. 4 figs. 1, 1a.—Lewinsohn, 1967: 178 *et seq.*, text-figs 1–13; 1969: 103, text-fig. 18f.

Galathea australiense.—Hale, 1927a: 78, text-fig. 74.

Diagnosis.—Anterior half of carapace with several uninterrupted transverse striae; a pair of anterior gastric spines but no other spines on dorsal surface. Rostrum nearly as broad as long, with three strong teeth on each lateral margin. Abdominal segments 2 and 3 with three transverse grooves. Terminal segment of antennular peduncle without a pronounced tuft of hairs. Merus of third maxillipeds with two strong spines on inner margin and two or three spinules on outer margin. Pereiopods 1–3 with an epipod.

Material.—Cliffy I. off Corner Inlet, Victoria; 16 October 1909; 1 ♂, E.1340.—Spencer Gulf, South Australia; 16 fms; 1913; 4 ♂, 1 ♀, E.4515.

Measurements.—Males 3.8 to 6.7 mm, female 5.7 mm.

Remarks.—Two males from E.4515 bear a sacculinid parasite which caused the development of female as well as male pleopods.

Distribution.—Lewinsohn (1967) gave a detailed description of this species and showed that records of *Galathea australiensis* from tropical Australia, as well as numerous extra-Australian ones, are all based on other forms. *G. australiensis* appears to be confined to temperate Australian waters. Reliable records include the following: New South Wales at Port Stephens (Haswell, 1882b) and Port Jackson (Stimpson, 1858, 1907; Haswell, 1882b; Miers, 1884; Grant and McCulloch, 1906; Lewinsohn, 1967); Port Phillip, Victoria (Sayce, 1902; Grant and McCulloch, 1906); Flinders Island and elsewhere off the coast of South Australia (Miers, 1884; Hale, 1927a); and possibly Shark Bay, Western Australia (Miers, 1884). The species occurs in shallow water.

Galathea balssi Miyake and Baba, 1964

Fig. 2 a-f

Galathea australis.—Balss, 1913: 2 (error for *australiensis*).

Galathea australiensis.—Balss, 1913: 13, text-fig. 13.

Galathea balssi Miyake and Baba, 1964: 205, text-figs 1, 2; 1967: 228.

?*Galathea whiteleggei*.—Tirmizi, 1966: 175, 186, text-fig. 9.

Diagnosis.—Anterior half of carapace with several uninterrupted transverse striae; one or two pairs of small anterior gastric spines, and a spine toward each end of the second continuous stria. Rostrum about one and a half times as long as broad or slightly longer, with three strong teeth on each lateral margin. Abdominal segments 2 and 3 with a median transverse groove. Terminal segment of antennular peduncle with a long tuft of hairs on outer distal margin. Merus of third maxillipeds with two spines on inner margin, the proximal one larger; two smaller spines on outer margin. Epipod wanting on all pereiopods.

Material.—E of Rockhampton, Queensland; 17 fms; 1913; 1 ♀, E.4514.

Measurements.—Ovigerous female 6.7 mm.

Remarks.—The single specimen from the *Endeavour* collection agrees closely with the description and illustrations of *Galathea balssi* except in a few details. It shows considerably less development of short striae and scales between the major transverse striae of the carapace. There are two pairs of anterior gastric spines instead of a single pair. The rostrum is only about 1.5 times as long as broad (width measured at the base of the third, or proximal, pair of rostral teeth), whereas it is about 1.8 times as long as broad in the holotype and twice as long as broad in the specimen illustrated by Balss (1913: text-fig. 13). *G. balssi* is known from only a few specimens and it is too soon to determine whether these differences fall within the normal range of variation for the species.

A specimen from the Indian Ocean, doubtfully referred to *Galathea whiteleggii* by Tirmizi (1966), seems to be closer to *G. balssi*. It agrees with the latter species, and differs from *G. whiteleggii*, in the shape of the rostral and supraocular teeth and in the presence of a single transverse groove on abdominal segments 2 and 3. On the other hand, the merus of the third maxillipeds differs from that of typical *G. balssi* in having three spines instead of two on both the inner and outer margins. Although there are four small anterior gastric spines as in the Australian example of *G. balssi*, they are more or less equidistantly spaced instead of being grouped as shown in fig. 2a, this paper. Because of these differences, and because Tirmizi did not mention the number of epipods in her specimen, I hesitate to place it definitely with *G. balssi*.

With Tirmizi's record eliminated, *Galathea whiteleggii* Grant and McCulloch (fig. 2g) is known only from the Arafura Sea and the east Australian coast. It resembles *G. balssi* in having a narrow, scaly rostrum, setiferous striae on the eyestalks and a fringe of setae at the base of the corneas, a spine near each end of the second complete stria of the carapace, a tuft of hairs on the terminal segment of the antennular peduncle, and spine-tipped scales on the chelipeds. It differs sharply in the form of the rostral teeth: their outer side is markedly convex, and the incurving of the third, or proximal, pair causes the rostrum to be very narrow at the base. In *G. balssi* the outer margin of the rostral teeth is nearly straight and the rostrum is relatively broader at the base. *G. whiteleggii* is further distinguished by the following characters: the supraocular teeth are relatively broader than in *G. balssi*; there is an epipod on the chelipeds; the

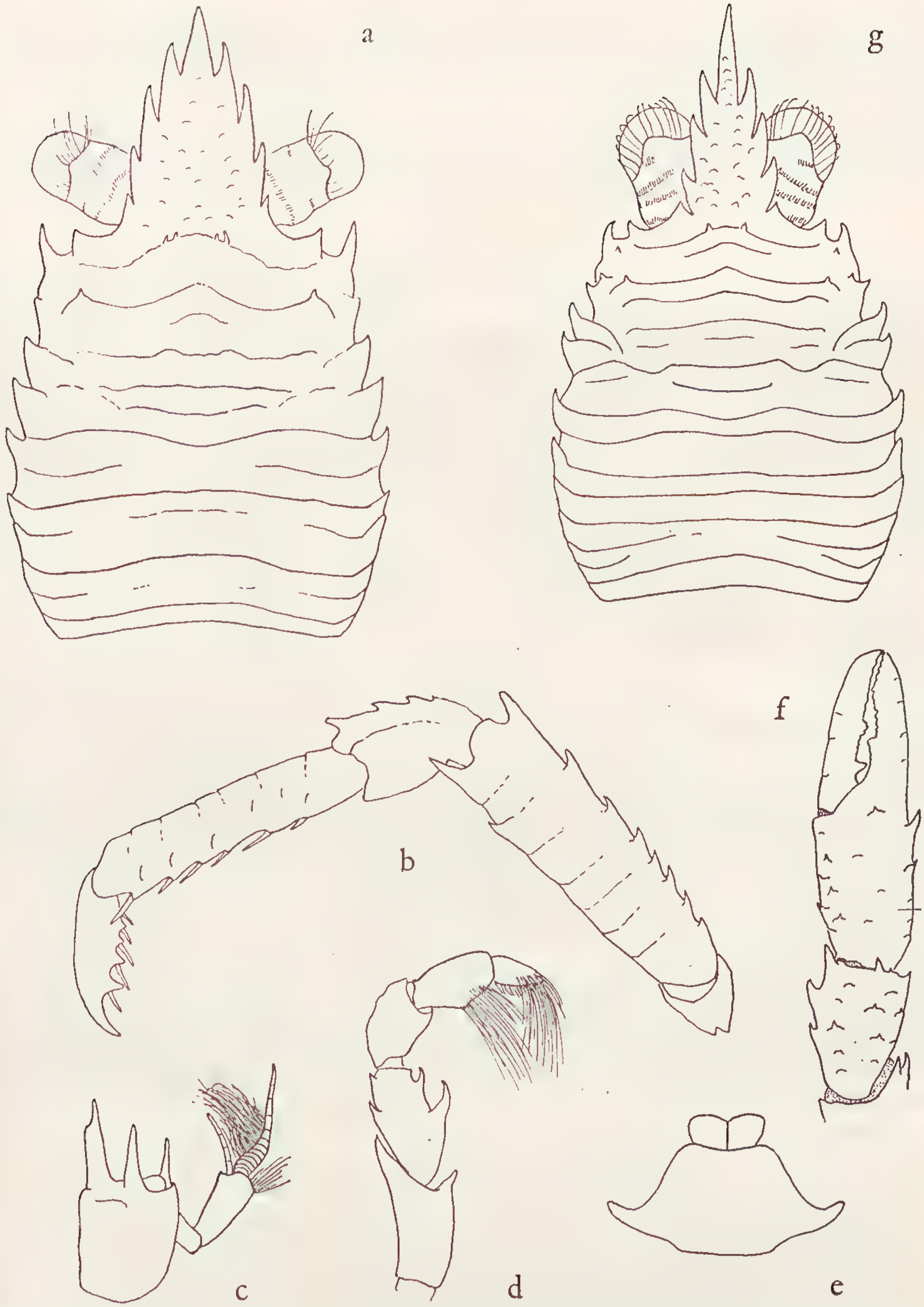


Figure 2.—a-f: *Galathea balssi* Miyake and Baba, female. Off Rockhampton, Queensland, E.4514. a, carapace, x12; b, left first walking leg, x16; c, right antennule, ventral view, x16; d, right third maxilliped, ventral view, x16; e, sternum of third maxillipeds and first pereiopods, x16; f, carpus and chela of right cheliped, x7. g: *Galathea whiteleggii* Grant and McCulloch, male. Off Dunwich, Moreton Bay, Queensland, 4 fms, 1946, coll. J. S. Hynd, P.15815. Carapace, x14½

merus of the outer maxillipeds is armed with three subequal spines on the inner margin; and there are three distinct transverse grooves on abdominal segments 2 and 3. In all specimens I have seen the carapace striae are very pronounced and fringed with long setae, but this character is probably subject to some variation.

Distribution.—*Galathea balssi* was previously reported from Japan and the East China Sea in 84 to 150 metres; its known range is now extended to the coast of Queensland where it was taken at a depth of about 31 metres.

Galathea aculeata Haswell, 1882

Galathea aculeata Haswell, 1882a: 761; 1882b; 162.—Whitelegge, 1900: 190.—Grant and McCulloch, 1906: 43, 48, pl. 4 figs. 4, 4a.—McNeill, 1968: 33.

?*Galathea australiensis*.—Miers, 1884: 277 (in part).

Diagnosis.—Striae on anterior half of carapace broken up into short, rounded scales; a pair of anterior gastric spines, and several other small spines on dorsal surface. Rostrum about one and a half times as long as broad, with three strong teeth on each lateral margin. Abdominal segments 2 and 3 with a median transverse groove. Terminal segment of antennular peduncle with a long tuft of hairs on outer distal margin. Merus of third maxillipeds with two or three strong spines on inner margin and two or three smaller, but distinct, spines on outer margin. Pereiopods 1–3 with an epipod.

Material.—18 miles NW of Double Island Point, Queensland; 17 fms; 1913; 1 ♀, P.17561.

Measurements.—Ovigerous female 4.3 mm.

Distribution.—This species has been reported from a relatively small area on the Queensland coast, between Lookout Point and Port Molle in Whitsunday Passage (Haswell, 1882a, 1882b; McNeill, 1968), in depths down to 20 fathoms (36 metres). According to Lewinsohn (1967: 178), the material from Port Denison and Port Molle attributed to *Galathea australiensis* by Miers (1884: 277) is probably *G. aculeata*. The known range is now extended for a considerable distance southward on the Queensland coast. I have examined material from Western Australia and Northern Territory.

Tirmizi (1966: 178, text-figs 3, 4) reported *Galathea aculeata* from the Red Sea, but her identification is questioned by Lewinsohn (1969: 111). Johnson (1970: 4) reported it from Singapore; this record should be left in doubt pending re-examination of his material, since Johnson made no mention of certain critical characters such as the presence or absence of epipods and of a tuft of hairs on the terminal segment of the antennular peduncle.

Galathea magnifica Haswell, 1882

Galathea magnifica Haswell, 1882a: 761; 1882b: 162.—Whitelegge, 1900: 187.—Grant and McCulloch, 1906: 43, 47, pl. 4 figs 3, 3a.—Balss, 1921: 23.—Hale, 1927a: 78, 79, text-fig. 75.

Galathea setosa Baker, 1905: 267, pl. 35 figs. 2, 2 a, b.

Diagnosis.—Striae on anterior half of carapace broken up into short, rounded scales; a pair of anterior gastric spines but usually no other spines on dorsal surface. Rostrum nearly as broad as long with three strong teeth on each lateral margin. Abdominal segments 2 and 3 with a median transverse groove. Terminal segment of antennular peduncle without a pronounced tuft of hairs. Merus of third maxillipeds with two strong spines on inner margin; outer margin unarmed. First pair of pereiopods with an epipod.

Material.—Between Port Stephens and Newcastle, New South Wales; 22–60 fms; 1 ♀, E.286.—Spencer Gulf, South Australia; 16 fms; 1913; 1 ♀, P.17562.

Measurements.—Females 4.8 and 6.6 mm.

Distribution.—Queensland off Mast Head Island, Capricorn Group, and at Port Curtis (Grant and McCulloch, 1906); New South Wales at Broughton Islands near Port Stephens (Haswell, 1882a, 1882b) and off Botany Bay (Whitelegge, 1900); Investigator Straits, South Australia (Baker, 1905); off Cape Jaubert, Western Australia (Balss, 1921). The known bathymetric range is 7 to 43 fathoms (13 to 77 metres). The species has not been reported outside of Australia.

Key to Species of Galathea known from Eastern Australia

1 Anterior gastric spines present 2
— No anterior gastric spines 8
2 (1) Anterior half of carapace with uninterrupted transverse striae 3
— Anterior half of carapace with short, curved scales only 7
3 (2) Second complete stria unarmed 4
— Second complete stria with a spine toward each lateral margin 6
4 (3) Antennular peduncle with a terminal tuft of hairs; chelipeds with an epipod .... *G. corallicola*
(Haswell, 1882a: 761; Whitelegge, 1900: 190.)
— Antennular peduncle without a terminal tuft 5
5 (4) Pereiopods 1–3 with an epipod .... *G. australiensis*
— Epipod wanting on all pereiopods .... *G. affinis*
(Ortmann, 1892: 252, pl. 11 fig. 9; Miyake and Baba, 1966: 57, text-figs. 1, 2; Lewinsohn, 1969: 112, text-fig. 21).
6 (3) Merus of third maxillipeds with two spines on inner margin; epipod wanting on all pereiopods .... *G. balssi*
— Merus of third maxillipeds with three spines on inner margin; chelipeds with an epipod .... *G. whiteleggii*
(Grant and McCulloch, 1906: 45, pl. 4 fig. 2.)
7 (2) Merus of third maxillipeds spined on outer margin; pereiopods 1–3 with an epipod .... *G. aculeata*
— Merus of third maxillipeds unarmed on outer margin; an epipod on chelipeds only .... *G. magnifica*
8 (1) Carapace with about 12 transverse striae; carapace and abdomen with five dark and four light longitudinal stripes .... *G. minuta*
(Potts, 1915: 87, pl. 1 fig. 6, text-fig. 4B. Perhaps = *G. amboinensis* De Man, 1888: 457, pl. 19 fig. 3).
— Carapace with about eight transverse striae; carapace and abdomen dark, with a broad light longitudinal stripe on each side of the midline .... *G. inflata*
(Potts, 1915: 85, pl. 1 fig. 7, text-fig. 4C; Baba, 1969b: 33, text-figs. 1, 2).

Phylladiorhynchus Baba, 1969

Phylladiorhynchus pusillus (Henderson, 1885)

Galathea pusilla Henderson, 1885: 407; 1888: 121, pl. 12 figs 1, 1 a, b.—Whitelegge, 1900: 185.—Grant and McCulloch, 1906: 43, 49, pl. 4 figs 5, 5a.—McNeill, 1926: 305.—Hale, 1927a: 78, 80.—Guiler, 1952: 36.—Miyake and Baba, 1967: 234, text-fig. 6.—Lewinsohn, 1967: 179.—Zarenkov, 1968: 177, text-fig. 22; 1970: 176, text-fig. 22.

Galathea integra Benedict, 1902: 247, 248.

Phylladiorhynchus pusillus.—Baba, 1969a: 4.

Diagnosis.—Anterior half of carapace with a few uninterrupted transverse striae; two pairs of anterior gastric spines, the small outer pair sometimes wanting. Rostrum narrow, with a single marginal spine on each side near tip; unarmed portion of lateral margins somewhat convex. Abdominal segments 2 and 3 with a median transverse groove. Terminal segment of antennular peduncle with a long fringe of hairs on outer distal margin. Merus of third maxillipeds with a submedian spine on inner margin and a distal spine on outer margin. Epipod wanting on all pereiopods.

Material.—S of Cape Everard, Victoria; 1 ♂, E.6158.—S and SW of Mt Cann, Gippsland, Victoria; 70–100 fms; 2 ♂, 1 ♀, P.17563.—About 15 miles SE of St Helens Point, Tasmania; 60 fms; 1 ♀, E.6170.

Measurements.—Males 5.0 to 6.9 mm, females 4.7 and 5.0 mm.

Remarks.—Two males, one from E.6158 and the other from P.17563, are parasitized by a sacculinid which is attached to the abdomen. In each case, female as well as male pleopods are developed. The presence of rhizocephalan parasites in this species was previously reported by Henderson (1888) and Whitelegge (1900).

Distribution.—Queensland at Capricorn Group (Grant and McCulloch, 1906; McNeill, 1926) and near Port Curtis (Lewinsohn, 1967); New South Wales off Bondi (Whitelegge, 1900), off Twofold Bay, 36° 59′S., 150° 20′E. (Henderson, 1885, 1888), and at 37° 40′S., 150° 00′E. (Zarenkov, 1968, 1970); Victoria off Port Phillip Heads (Grant and McCulloch, 1906); D'Entrecasteaux Channel, Tasmania (Guiler, 1952); and South Australia between Beachport and the Althorps (Hale, 1927a). I have examined specimens from several localities in Western Australia.

The species is also reported from New Zealand, from Japan, and from Providence Island in the Indian Ocean. Specimens from the Red Sea which Tirmizi (1966: 175) identified as *Galathea pusilla* undoubtedly belong to another species, as Lewinsohn (1969: 116) and Baba (1969a: 5) have already pointed out. *Phylladiorhynchus pusillus* has been found in the littoral and in depths to about 170 fathoms (310 metres); it appears to be common only in deeper water.

Family **PORCELLANIDAE**

Pachycheles Stimpson, 1858

Pachycheles sculptus (H. Milne Edwards, 1837)

Porcellana sculpta H. Milne Edwards, 1837: 253.—Studer, 1889: 185, 232.

Porcellana pisum H. Milne Edwards, 1837: 254.—Studer, 1889: 185.

Porcellana pulchella Haswell, 1882a: 758; 1882b: 148.

Pachycheles pulchellus.—Miers, 1884: 273, pl. 30 fig. A.—Henderson, 1888: 114.—Ortmann, 1894: 29, 30.—McNeill, 1968: 34.

Pachycheles pisum.—Rathbun, 1924: 30.—Ward, 1928: 245.

Pachycheles sculptus.—Haig, 1965: 102.—Nakasone and Miyake, 1968a: 61, pl. 5 figs 1–3, text-fig. 1.

Diagnosis.—See Haig, 1965: 102.

Material.—11–14 miles NW of Pine Peak, Queensland; 24–26 fms; 1912; 1 ♂, E.3194.—18 miles NW of Double Island Point, Queensland; 17 fms; 1913; 1 ♂, 3 ♀, P.17564.

Measurements.—Males 4.0 and 4.7 mm, non-ovigerous female 6.1 mm, ovigerous females 3.6 and 7.2 mm.

Remarks.—All five specimens from the *Endeavour* collection are of the "*pulchellus*" variety described and illustrated by Miers (1884).

Distribution.—This species is reported from Western Australia between Cottesloe and Troughton Island (Studer, 1889; Rathbun, 1924; Haig, 1965); off Bathurst Island, Northern Territory (Nakasone and Miyake, 1968a); Arafura Sea (Henderson, 1888; Nakasone and Miyake, 1968a); and Queensland from Torres Strait south to Bunker Group (Haswell, 1882a, 1882b; Miers, 1884; Henderson, 1888; Ortmann, 1894; Ward, 1928; McNeill, 1968). The known range is now extended southward along the Queensland coast.

Outside of Australia the species is known from Mergui Archipelago in the Indian Ocean, from the Ryukyu Islands south to the East Indian Archipelago, and eastward to the Tuamotu Archipelago. It is usually found in the littoral or at moderate depths, but has been reported from between 50 and 100 fathoms (about 90 to 180 metres).

Pisidia Leach, 1820

Pisidia gordoni (Johnson, 1970)

Porcellana (allied to *serratifrons*).—Miers, 1884: 277.

Porcellana serratifrons.—Henderson, 1888: 110 (in part: Arafura Sea specimen).—Grant and McCulloch, 1906: 39, 40.—McNeill, 1968: 34.

Porcellana spinulifrons.—Gordon, 1931: 530, text-figs. 4C, 5.

Pisidia cf. *spinulifrons*.—Haig, 1965: 105, 106.

Porcellana (*Pisidia*) *gordoni* Johnson, 1970: 29, fig. 3 m-p.

Diagnosis.—See Haig, 1965: 106.

Material.—Great Sandy Strait off Point Inskip, Queensland; 10 fms; 27 July 1910; 1 ♂, E.3185.

Measurements.—Male 4.2 mm.

Remarks.—This species has only recently been provided with a name and complete description, based on material from Singapore. It was named in honour of Dr Isabella Gordon. A few years ago a change in spelling to *gordonae* would have been required under Article 31 of the International Code of Zoological Nomenclature; but that article is now a Recommendation and the spelling *gordoni* must apparently stand.

Distribution.—Between Onslow and Broome, Western Australia (Haig, 1965); Northern Territory (Haig, 1965); Arafura Sea (Henderson, 1888); Queensland between Thursday Island and Mast Head Island, Capricorn Group (Miers, 1884; Grant and McCulloch, 1906; McNeill, 1968).

This species also occurs from the east coast of Africa eastward to the East Indian Archipelago, and along the east Asian coast as far north as Hong Kong. The bathymetric range is littoral to about 40 fathoms (72 metres).

Pisidia dispar (Stimpson, 1858)

Porcellana dispar Stimpson, 1858: 229, 242; 1907: 190, pl. 23 fig. 3.—Haswell, 1882b: 149.—Miers, 1884: 275, pl. 30 fig. C.—Whitelegge, 1889: 231.—Stead, 1898: 208.—Grant and McCulloch, 1906: 40.—Rathbun, 1924: 31.—Hale, 1927a: 82, text-fig. 79; 1927b: 309.

Porcellana rostrata Baker, 1905: 260, pl. 35 figs. 1, 1 a, b.

Pisidia dispar.—Haig, 1965: 105, 107.—McNeill, 1968: 34.—Nakasone and Miyake, 1968b: 97, text-fig. 1.—Shepherd, 1969: 107 *et seq.*, text-figs 6–9.

Diagnosis.—See Haig, 1965: 107.

Material.—Cape Marsden, Kangaroo I., South Australia; 17 fms; 18 August 1909; 3 ♂, 2 ♀, E.4522.—Sanders Bank, Kangaroo I.; 28 fms; 1913; 9 ♂, 6 ♀, 1 juv., E.4524.—15 miles NW of Cape Jervis, South Australia; 17 fms; 1913; 17 ♂, 6 ♀, 1 intersex, E.4520.

Measurements.—Males 1.7 to 5.3 mm, non-ovigerous females 3.1 to 5.2 mm, ovigerous female 3.2 mm.

Remarks.—An intersex, with carapace 4.4 mm long, from E.4520 has both male and female pleopods on the abdomen, and a rather poorly developed female genital opening on the coxa of each third pereiopod. The secondary sexual characters, such as the form of the chelipeds, are male.

Ten of the 24 individuals from E.4520 are parasitized with a bopyrid; half have the parasite in the left branchial chamber, half in the right. One specimen from E.4522 is similarly infected. A male from E.4524 has a sacculinid attached to the abdomen, accompanied by secondary development of female pleopods; in this specimen there is no trace of female genital pores.

Distribution.—Queensland at Low Isles and Batt Reef (McNeill, 1968), Port Curtis (Grant and McCulloch, 1906), and Dunwich, Moreton Bay (Shepherd, 1969); New South Wales at Port Stephens (Haswell, 1882b) and Port Jackson (Stimpson, 1858, 1907; Haswell, 1882b; Miers, 1884; Whitelegge, 1889; Stead, 1898); South Australia at Investigator Straits (Baker, 1905; Hale, 1927b) and Kangaroo Island (Hale, 1927b); Western Australia between Warnbro Sound and Broome (Rathbun, 1924; Haig, 1965).

Pisidia dispar was known only from Australia until recently, when Nakasone and Miyake (1968b) reported it from the Ryukyu Islands and the main island of Japan. The bathymetric range is littoral to about 30 fathoms (54 metres).

Aliaporcellana Nakasone and Miyake, 1969

Aliaporcellana suluensis (Dana, 1852)

Porcellana suluensis Dana, 1852: 414; 1855: pl. 26 fig. 4.—Rathbun, 1924: 30, pl. 1 figs 15, 16.

Polyonyx denticulatus Paulson, 1875: 89, pl. 11 fig. 6; 1961: 95, pl. 11 fig. 6.—Johnson, 1958: 98, 100, text-fig. 1.

Polyonyx hexagonalis Zehntner, 1894: 187, pl. 8 figs 18, 18a.

Polyonyx suluensis.—Haig, 1965: 112.—McNeill, 1968: 37.—Lewinsohn, 1969: 166, text-fig. 37.

Aliaporcellana suluensis.—Nakasone and Miyake, 1969: 19, 21, text-fig. 1.

Diagnosis.—See Haig, 1965: 112.

Material.—7 miles NNE of Bowen, Queensland; 16 fms; 3 August 1910; 1 ♂, E.3115.—18 miles NW of Double Is. Point, Queensland; 17 fms; 1913; 2 ♂, 1 ♀, E.4521.

Measurements.—Males 3.0 to 4.8 mm, ovigerous female 5.0 mm.

Remarks.—The 4.8 mm male from E.3115 has a sacculinid attached to the abdomen.

Distribution.—The species is reported from Australia off Cape Jaubert, Western Australia (Rathbun, 1924; Haig, 1965) and off Lookout Point, Queensland (McNeill, 1968). The known range is now extended for a considerable distance southward along the Queensland coast.

The general distribution for the species is Indian Ocean, including the Red Sea, and western Pacific from Kyushu Island, Japan, south to the East Indian Archipelago. It has been collected in the littoral and to depths of at least 70 fathoms (126 metres).

Polyonyx Stimpson, 1858

Polyonyx obesulus Miers, 1884

Porcellana obesula White, 1847: 130 (nomen nudum).

Polyonyx obesulus Miers, 1884: 272, pl. 29 fig. D.—Henderson, 1888: 115.—Johnson, 1958: 99, 108, text-fig. 4.—Haig, 1965: 112, 113.—McNeill, 1968: 37.

Polyonyx parvidens Nobili, 1905: 161.

Diagnosis.—See Haig, 1965: 113.

Material.—18 miles NW of Double Is. Point, Queensland; 17 fms; 1913; 1 ♀, P.17565.

Measurements.—Length of female 5.9 mm, width 8.1 mm.

Distribution.—From vicinity of Geraldton to off Troughton Island, Western Australia (Haig, 1965); Port Darwin, Northern Territory (Miers, 1884); Queensland from Flinders Passage south to Port Denison (Miers, 1884; Henderson, 1888; McNeill, 1968). The known range is now extended southward on the coast of Queensland.

Polyonyx obesulus is known from the Indian Ocean, including the Gulf of Iran, and in the western Pacific from the Philippine Islands south to the East Indian Archipelago. The bathymetric range is littoral to about 30 fathoms (54 metres).

ACKNOWLEDGMENTS

This study was supported in part by National Science Foundation Grant GB-6900, which made possible a trip to Australia during which I visited and studied collections in several museums. Later phases of the work were carried out with the aid of National Science Foundation Grant GB-16386. I am grateful for the help provided by NSF, and by those persons who assisted me in various ways. J. C. Yaldwyn provided working space during my visit to the Australian Museum in 1968 and made the *Endeavour* collection available to me for study. Additional material from the *Endeavour* was received from R. W. George of the Western Australian Museum. D. J. G. Griffin of the Australian Museum, and R. B. Manning of the Smithsonian Institution, provided various kinds of information. Francis Munger took the photographs from which some of the illustrations were prepared.

REFERENCES

Adams, A., and White, A. 1848. Crustacea: viii, 66, 13 pls. In A. Adams (ed.), The zoology of the voyage of H.M.S. Samarang; under the command of Captain Sir Edward Belcher, C.B., F.R.A.S., F.G.S., during the years 1843–1846. Benham and Reeve, London.

Alcock, A., 1894. Natural history notes from H.M. Indian Marine Survey steamer "Investigator," Commander R. F. Hoskyn, R.N., late commanding.—Series II, No. 1. On the results of the deep-sea dredging during the season 1890–91 (continued). *Ann. Mag. nat. Hist.* (6) 13: 321–334.

——— 1901. A descriptive catalogue of the Indian deep-sea Crustacea Decapoda Macrura and Anomala, in the Indian Museum. Being a revised account of the deep-sea species collected by the Royal Indian Marine Survey ship Investigator. Indian Museum, Calcutta. Pp. 286, iv, 3 pls.

Alcock, A., and Anderson, A. R. S., 1895. Crustacea: pls. 9–15. In Illustrations of the zoology of the Royal Indian marine surveying steamer Investigator. Part 3. Superintendant of Govt Printing, Calcutta.

Baba, K., 1969a. Four new genera with their representatives and six new species of the Galatheidae in the collection of the Zoological Laboratory, Kyushu University, with redefinition of the genus *Galathea*. *Ohmu* 2: 1–32, 9 figs.

——— 1969b. New addition to the galatheid fauna of Japan (Crustacea, Anomura). *Ohmu* 2: 33–40, 4 figs.

Baker, W. H., 1905. Notes on South Australian decapod Crustacea. Part III. *Trans. R. Soc. S. Aust.* 29: 252–269, pls 32–36.

Balss, H., 1913. Beiträge zur Naturgeschichte Ostasiens. Ostasiatische Decapoden I. Die Galatheiden und Paguriden. *Abh. bayer. Akad. Wiss.* Suppl. 2 (9): 1–85, pls. 1–2, 56 figs.

——— 1921. Results of Dr E. Mjöbergs Swedish scientific expeditions to Australia 1910–13. XXIX. Stomatopoda, Macrura, Paguridea und Galatheidea. *K. svenska VetenskAkad. Handl.* (n.s.) 61 (10): 1–24, 12 figs.

Benedict, J. E., 1902. Descriptions of a new genus and forty-six new species of crustaceans of the family Galatheidae, with a list of the known marine species. *Proc. U.S. natn. Mus.* 26: 243–334, 47 figs.

Dana, J. D., 1852. Crustacea. United States Exploring Expedition during the years 1838, 1839, 1840, 1841, 1842 under the command of Charles Wilkes, U.S.N. Vol. 13, Part I: pp. viii, 685. C. Sherman, Philadelphia.

——— 1855. Crustacea, Atlas. United States Exploring Expedition during the years 1838, 1839, 1840, 1841, 1842 under the command of Charles Wilkes, U.S.N. Vol. 14: pp. 27, 96 pls. C. Sherman, Philadelphia.

Filhol, H., 1885. Mission de l'Ile Campbell. Crustacés: 349–510. Recueil de mémoires, rapports et documents relatifs à l'observation du passage de Vénus sur le soleil du 9. Décembre 1874. Vol. 3, Part 2. Institut de France, Paris.

Gillett, K., 1968. The Australian Great Barrier Reef in colour. A. H. and A. W. Reed, Sydney, Wellington, and Auckland. Pp. 112, frontispiece plus 66 pls.

Gordon, Isabella, 1931. Brachyura from the coasts of China. *J. Linn. Soc., Zool.* 37: 525–558, 36 figs.

Grant, F. E., and McCulloch, A. R., 1906. On a collection of Crustacea from the Port Curtis district, Queensland. *Proc. Linn. Soc. N.S.W.* 31: 2–53, pls. 1–4.

Guiler, E. R., 1952. A list of the Crustacea of Tasmania. *Rec. Queen Vict. Mus.* 3: 15–44.

Haig, Janet, 1965. The Porcellanidae (Crustacea, Anomura) of Western Australia with descriptions of four new Australian species. *J. Proc. R. Soc. West. Aust.* 48: 97–118, 3 figs.

Hale, H. M., 1927a. The crustaceans of South Australia. Part I: pp. 201, 202 figs. Govt Printer, Adelaide.

——— 1927b. The fauna of Kangaroo Island, South Australia. No. 1. The Crustacea. *Trans. R. Soc. S. Aust.* 51: 307–321, 7 figs.

——— 1941. Decapod Crustacea. *Rep. B.A.N.Z. antarct. Res. Exped.* (B) 4: 257–285, 16 figs.

Haswell, W. A., 1882a. Description of some new species of Australian Decapoda. *Proc. Linn. Soc. N.S.W.* 6: 750–763.

——— 1882b. Catalogue of the Australian stalk- and sessile-eyed Crustacea. Australian Museum, Sydney. Pp. xxiv, 326, 4 pls.

Healy, A. and Yaldwyn, J., 1970. Australian crustaceans in colour. A. H. and A. W. Reed, Sydney, Melbourne, Wellington, and Auckland. Pp. 112, frontispiece plus 52 pls, 57 figs.

Henderson, J. R., 1885. Diagnoses of the new species of Galatheidea collected during the "Challenger" Expedition. *Ann. Mag. nat. Hist.* (5), 16: 407–421.

——— 1888. Report on the Anomura collected by H.M.S. Challenger during the years 1873–76. *Rep. Zool. Challenger Exped.* 27: pp. xi plus 221, 21 pls.

Johnson, D. S., 1958. The Indo-West Pacific species of the genus *Polyonyx* (Crustacea, Decapoda, Porcellanidae). *Ann. Zool., Agra* 2: 95–118, 4 figs.

——— 1970. The Galatheidea (Crustacea: Decapoda) of Singapore and adjacent waters. *Bull. natn. Mus. St. Singapore* 35: 1–44, 6 figs.

Lagerberg, T., 1905. Anomoura und Brachyura der schwedischen Südpolar-Expedition. *Wiss. Ergebn. schwed. Südpolarexped.* 5 (7): 1–39, pl. 1.

Lewinsohn, Ch., 1967. Beitrag zur Kenntnis und Verbreitung von *Galathea australiensis* Stimpson, 1858 (Crustacea Decapoda, Anomura, Galatheidae) nebst Beschreibung eines Neotypus. *Zool. Meded., Leiden* 42: 175–187, 13 figs.

——— 1969. The second Israel South Red Sea Expedition, 1965. Report No. 6. Die Anomuren des Roten Meeres (Crustacea Decapoda: Paguridea, Galatheidea, Hippidea). *Zool. Verh., Leiden* 104: pp. 213, 2 pls, 37 figs, 3 maps.

McNeill, F. A., 1926. The biology of North-west Islet, Capricorn Group. *Aust. Zool.* 4: 299–318, pl. 41, 2 figs.

——— 1968. Crustacea, Decapoda & Stomatopoda. *Scient. Rep. Gt Barrier Reef Exped.* 7 (1): 1–98, pls 1–2, 2 figs.

Man., J. G. de, 1888. Bericht über die von Herrn Dr J. Brock im indischen Archipel gesammelten Decapoden und Stomatopoden. *Arch. Naturgesch.* 53 (1): 215–600, pls 7–22, 22a.

——— 1902. Die von Herrn Professor Kükenthal im indischen Archipel gesammelten Dekapoden und Stomatopoden. *Abh. senckenb. naturforsch. Ges.* 25: 467–929, pls 19–27.

Matthews, L. R., 1932. Lobster-krill, anomuran Crustacea that are the food of whales. "*Discovery*" *Rep.* 5: 467–484, pl. 4, 1 fig.

Melin, G., 1939. Paguriden und Galatheiden von Prof. Dr Sixten Bocks Expedition nach den Bonin-Inseln 1914. *K. svenska VetenskAkad. Handl.* (3) 18 (2): 1–119, 71 figs.

Miers, E. J., 1874. Crustacea: pp. 5, 4 pls. In J. Richardson and J. E. Gray (eds), The zoology of the voyage of H.M.S. Erebus & Terror, under the command of Captain Sir James Clark Ross, during the years 1839 to 1843. Vol. 2. E. W. Janson, London.

——— 1884. Crustacea: 178–322, pls 18–34. In Report on the zoological collections made in the Indo-Pacific Ocean during the voyage of H.M.S. "Alert" 1881–2. British Museum, London.

Milne Edwards, H., 1837. Histoire naturelle des crustacés, comprenant l'anatomie, la physiologie et la classification de ces animaux. Vol. 2: pp. 531. Paris.

Miyake, S., and Baba, K., 1964. Two new species of *Galathea* from Japan and the East China Sea (Crustacea, Anomura). *J. Fac. Agric. Kyushu Univ.* 13: 205–211, 4 figs.

——— 1966. Descriptions of galatheids collected from coral reefs of the Ryukyu Islands (Crustacea, Anomura). *J. Fac. Agric. Kyushu Univ.* 14: 57–79, 14 figs.

——— 1967. Galatheids of the East China Sea (Chirostylidae and Galatheidae, Decapoda, Crustacea). *J. Fac. Agric. Kyushu Univ.* 14: 225–246, 13 figs.

Nakasone, Y., and Miyake, S., 1968a. On six species of *Pachycheles* (Anomura: Porcellanidae) from the West Pacific. *Ohmu* 1: 61–83, pls 5–6, 8 figs.

——— 1968b. Four unrecorded porcellanid crabs (Anomura: Porcellanidae) from Okinawa, the Ryukyu Islands. *Ohmu* 1: 97–111, 4 figs.

——— 1969. A new porcellanid crab (Anomura: Porcellanidae) from Japan (*Aliaporcellana kikuchii* gen. et sp. nov.), with description of two species of the new genus. *Publs Amakusa mar. biol. Lab., Kyushu Univ.* 2: 17–32, 4 figs.

Nobili, G., 1905. Décapodes nouveaux des côtes d'Arabie et du Golfe Persique (diagnoses préliminaires). *Bull. Mus. natn. Hist. nat., Paris* 11: 158–164.

Ortmann, A., 1892. Die Decapoden-Krebse des Strassburger Museums, mit besonderer Berücksichtigung der von Herrn Dr Döderlein bei Japan und bei den Liu-Kiu-Inseln gesammelten und zur Zeit im Strassburger Museum aufbewahrten Formen. IV. Die Abtheilungen Galatheidea und Paguridea. *Zool. Jb.*, Syst. 6: 241–326, pls 11–12.

——— 1894. Zoologische Forschungsreisen in Australien und dem Malayischen Archipel mit Unterstutzung des Herrn Dr Paul von Ritter ausgeführt in den Jahren 1891–1893 von Dr Richard Semon. Crustaceen. *Denkschr. med.-naturw. Ges. Jena* 8: 1–80, pls 1–3.

Paulson, O., 1875. Izsledovanija rakoobraznykh Krasnago Morja s zametkami otnositel'no rakoobraznykh drugikh morei. Chast I. Podophthalmata i Edriophthalmata (Cumacea). S. V. Kul'zhenko, Kiev. Pp. xv, 144, 21 pls.

——— 1961. Studies on Crustacea of the Red Sea with notes regarding other seas. Part I. Podophthalmata and Edriophthalmata (Cumacea). Israel Program for Scientific Translations, Jerusalem. Pp. iv, 164, 21 pls.

Potts, F. A., 1915. The fauna associated with the crinoids of a tropical coral reef: with especial reference to its colour variations. *Pap. Tortugas Lab.* 8: 71–96, pl. 1, 7 figs.

Rathbun, Mary J., 1924. Results of Dr E. Mjöberg's Swedish scientific expeditions to Australia 1910–1913. 37. Brachyura, Albuneidae and Porcellanidae. *Ark. Zool.* 16 (23): 1–33, pl. 1, 7 figs.

Sayce, O. A., 1902. Dredging in Port Phillip. *Victorian Nat.* 18: 149–155.

Schmitt, W. L., 1926. Report on the Crustacea Macrura (families Peneidae, Campylonotidae and Pandalidae) obtained by the F.I.S. "Endeavour" in Australian seas. With notes on the species of "*Penaeus*" described by Haswell and contained, in part, in the collections of the Macleay Museum, at the University of Sydney. *Biol. Res. Fish. Exp. "Endeavour"* 5: 311–381, pls 57–68, 1 map.

Shepherd, M. C., 1969. The larval morphology of *Polyonyx transversus* (Haswell), *Pisidia dispar* (Stimpson) and *Pisidia streptochiroides* (De Man) (Decapoda: Porcellanidae). *Proc. R. Soc. Qd* 80: 97–123, 12 figs.

Southwell, T., 1906. Report on the Anomura collected by Professor Herdman, at Ceylon, in 1902. *Rep. Govt Ceylon Pearl Oyster Fish. Gulf Manaar* 5: 211–224, 2 figs.

Stead, D. G., 1898. Notes on the habits of some of the Australian malacostracous Crustacea. *Zoologist* (4) 2: 202–212.

Stimpson, W., 1858. Prodromus descriptionis animalium evertebratorum, quae in Expeditione ad Oceanum Pacificum Septentrionalem, a Republica Federata missa, Cadwaladaro Ringgold et Johanne Rodgers Ducibus, observavit et descripsit. Pars VII. Crustacea Anomura. *Proc. Acad. nat. Sci. Philad.* 10: 225–252.

——— 1907. Report on the Crustacea (Brachyura and Anomura) collected by the North Pacific Exploring Expedition, 1853–1856. *Smithson. misc. Collns* 49 (3): 1–240, pls 1–26.

Studer, Th. (ed.), 1889. Zoologie und Geologie. Die Forschungsreise S.M.S. "Gazelle" in den Jahren 1874 bis 1876 . . . Vol. 3: pp. vi, 322, 33 pls. E. S. Mittler u. Sohn, Berlin.

Tirmizi, Nasima M., 1966. Crustacea: Galatheidae. *Scient. Rep. John Murray Exped.* 11: 169–234, 40 figs.

Ward, M., 1928. The Crustacea of the Capricorn and Bunker Groups, Queensland. *Aust. Zool.* 5: 241–246, pls 27–29, 1 fig.

White, A., 1847. List of the specimens of Crustacea in the collection of the British Museum. British Museum, London. Pp. viii, 143.

Whitelegge, T., 1889. List of the marine and fresh-water invertebrate fauna of Port Jackson and the neighbourhood. *J. Proc. R. Soc. N.S.W.* 23: 163–323.

——— 1900. Scientific results of the trawling expedition of H.M.C.S. "Thetis". Crustacea. Part I. *Mem. Aust. Mus.* 4: 133–199, pls 32–35, figs 11–14.

Yanagita, I., 1943. Revision of *Munida*, a genus of decapod crustaceans, found in Japanese waters. *Bull. biogeogr. Soc. Japan* 13: 13–32, 10 figs.

Yokoya, Y., 1936. Some rare and new species of decapod crustaceans found in the vicinity of the Misaki Marine Biological Station. *Jap. J. Zool.* 7: 129–146, 10 figs.

Zarenkov, N. A., 1968. Rezul'taty biologicheskikh issledovanii Sovetskoi Antarkticheskoi Ekspeditsii (1955–1958 gg.). 4. Desjatinogie rakoobraznye (Crustacea Decapoda), sobrannye Sovetskimi Antarkticheskimi Ekspeditsijami v Antarkticheskoi i antiboreal'noi oblastjakh. *Issledovanija Fauny Morei* 6: 153–199, 23 figs.

——— 1970. Crustacean Decapoda collected by the Soviet Antarctic Expeditions in the Antarctic and antiboreal regions. *Biol. Rep. Soviet Antarctic Exped.* 4: 153–201, 23 figs. Israel Program for Scientific Translations, Jerusalem.

Zehntner, L., 1894. Voyage de MM. M. Bedot et C. Pictet dans l'Archipel Malais. Crustacés de l'Archipel Malais. *Revue suisse Zool.* 2: 135–214, pls 7–9.

NATIONAL MUSEUM
23 JUL 1973
OF VICTORIA

THE ALPHEID SHRIMP OF AUSTRALIA

Part 1: The Lower Genera

By DORA M. and ALBERT H. BANNER

Hawaii Institute of Marine Biology, University of Hawaii, Honolulu

Figures 1–19. Manuscript received 7th September, 1971.

This study is dedicated to the memory of our son, Alan Conrad Banner, who, while serving in the United States Peace Corps, was killed in a shark attack at Aliepata, Western Samoa, on 15th April, 1972. At the age of 25, Alan was training to become a marine biologist as he wished to contribute to the development of the potential tropical marine fisheries to aid the island peoples of the Pacific.

SUMMARY

This is the first section of a three-part monograph on the alpheid shrimp of Australia. The study is based upon a collection of 5,000 to 6,000 specimens, in part on loan from various institutions and individuals and in part collected by the authors. For each species recognitional characteristics are described and depicted, notes are given on taxonomy, variation, and biology, and the Australian and world distribution is listed. The present paper deals with lower genera; the future two papers will deal with *Synalpheus* and *Alpheus* respectively.

This paper discusses the following genera and species, those species marked with an asterisk being either new species or new records for the Australian continent:

**Automate dolichognatha* De Man
**Athanas areteformis* Coutière
Athanas djiboutensis Coutière

**Athanas japonicus* Kubo
**Athanas locincertus* sp. nov.
**Athanas dimorphus* Ortmann
Athanas haswelli Coutière
Athanas granti Coutière
**Athanas ornithorhynchus* sp. nov.
**Athanas sibogae* De Man
**Athanas dorsalis* (Stimpson)
Athanas indicus Coutière
**Aretopsis amabilis* De Man
**Salmoneus tricristatus* Banner
Alpheopsis trispinosus (Stimpson) [neotype established]
**Alpheopsis undicola* sp. nov.
**Alpheopsis equalis* Coutière
**Alpheopsis yaldwyni* sp. nov.
Betaeus australis Stimpson [neotype established]
**Racilius compressus* Paulson

In addition to these records of new species and neotypes, we have placed the following species in synonymy:

Automate gardineri Coutiere (= *A. dolichognatha* de Man)
Athanas setoensis Kubo (= *A. dimorphus* Ortmann)
Athanas dimorphus seedang (= *A. dimorphus* Ortmann)
Aretopsis aegyptica Ramadan (= *A. amabilis* de Man)

We have accepted *A. sibogae* as the proper name for *A. parvus*, based on page priority (see Banner and Banner, 1960 and Miya and Miyake, 1968).

CONTENTS

Page

Introduction 294
  Adequacy of Sampling 294
  General Notes on Alpheid Shrimp 295
  General Distribution and Ecology 296
  Support and Acknowledgements 297

The Family Alpheidae 298
  Key to the Genera 298

The Genus *Automate* 299
  A. dolichognatha De Man 299

The Genus *Athanas* 303
  Key to the Species 303
  A. areteformis Coutière 304
  A. djiboutensis Coutière 306
  A. japonicus Kubo 308
  A. locincertus sp. nov. 311
  A. dimorphus Ortmann 313
  A. haswelli Coutière 316
  A. granti Coutière 316
  A. ornithorhynchus sp. nov. 319
  A. sibogae De Man 321
  A. dorsalis (Stimpson) 324
  A. indicus (Coutière) 327

The Genus *Aretopsis* 330
  A. amabilis De Man 330

The Genus *Salmoneus* 334
  S. tricristatus Banner 334

The Genus *Alpheopsis* 336
  Key to the Species 337
  A. trispinosus (Stimpson) [neotype established] 337
  A. undicola sp. nov. 340
  A. equalis Coutière 342
  A. yaldwyni sp. nov. 344

The Genus *Betaeus* 347
  B. australis Stimpson [neotype established] 347

The Genus *Racilius* 350
  R. compressus Paulson 350

Appendix—Locality Lists for the Alpheid collection 353

INTRODUCTION

The snapping or pistol shrimp were previously put into a single family, the Alpheidae (Crangonidae of some authors from 1904 to 1955). This family was united with the Hippolytidae and a newly created family, the monogeneric Ogyridae, into the superfamily Alpheoida by Holthuis in 1955; the superfamily belongs to the section Caridae and the supersection Natantia of the order Decapoda. The hippolytids have not been closely associated with the alpheids; however, the genus *Ogyrides* Stebbing (*Ogyris* Stimpson) was considered to be within the family Alpheidae until its separation by Holthuis. For that reason we will append notes on *Ogyrides mjoebergi* (Balss) from Australia at the end of the monograph.

This study, which will cover all species previously reported from Australian waters as well as our new records and new species, will be issued in three parts; this initial portion is confined to the lower genera, but contains the locality records for the entire paper as well as the key to the genera. We plan the second section to contain nothing but the species of the genus *Synalpheus*, and the third will be devoted to Australian species of the genus *Alpheus*. In the third section we will also have the bibliography for the entire study and a discussion of Australian distribution of all the species with respect to Australian faunal provinces.

Our primary purpose for studying the Australian alpheids is as a part of a continuing study of coral reef biota in the tropical Indo-Pacific in which we will use these abundant shrimp as index organisms to indicate broad zoogeographic realms and provinces. Our second purpose is to provide future workers in Australia with a monographic guide to these shrimp in their waters. For the first aim, a simple species list with localities and descriptions of new species would have been adequate; however, for later workers we have provided keys, descriptions, illustrations, and references to all important descriptive works on the species as well as all previously published Australian records. We have given reported world distribution for each species and have added such biological notes as available.

Adequacy of Sampling

Previous to this work 30 species from the family had been recorded from Australia in the literature; this work will increase the number to about 100 (this total is approximate, as the final work on *Synalpheus* and *Alpheus* is yet to be done). Our study collection was primarily on loan from each of the Australian museums. We also received specimens from many of the universities and from individuals (see *Acknowledgements* below). These collections we were able to supplement by personal collections made in Australia during three months in 1967–68. The total collections available amounted to between 5,000 and 6,000 individual specimens.

Our collections have come from every State in Australia, as well as Lord Howe Island and Norfolk Island. We have not included any records from New Zealand or New Guinea, although some of the museum collections include specimens from those localities.

As large as is this total, we have no hope that we have seen every species occurring off the coasts of the sub-continent, or that we have been able to delimit the extent of distribution for any species. The degree that these collections will represent the alpheid fauna will vary with region, for as any Australian worker knows the fauna of the Great Barrier Reef is more thoroughly sampled than that on reefs of the Northern Territory and the northern part of Western Australia. We also had but few samples from the Great Australian Bight, but whether that was solely because of the infrequency of collecting there, or whether the infrequency of collection was combined with an expected paucity of shrimp, we do not know.

In all, we hope that we have almost all of those species that occur normally in the usually examined habitats. We would hazard, from the basis of our previous studies, that we are reporting on perhaps ninety per cent of the species that eventually will be known from Australia. However, there are still many habitats, such as deeper muddy bottoms, that may yield many unrecorded species. We hope that with the tool that this monograph may be, future workers will be able to make the listing more exhaustive.

General Notes on Alpheid Shrimp

The definition of the family is given on p. 298; here it will suffice to state that, while the lower genera of the family may be difficult to recognize except by careful examination under the microscope, the two higher genera *Synalpheus* and *Alpheus* almost always can be recognized by the excessive size and asymmetrical development of their large chelae. In these two genera, the dactylus (free finger) of this chela carries a rounded plunger that can be thrust into a socket at the base of the fixed finger; the violent closure of the chela produces a loud snapping, clearly audible under water and even when the hearer is out of water and walking across a tide flat. The mechanism of this sound production has been somewhat controversial (see Knowlton and Moulton, 1963) but Bowers, 1970, believes the primary production of sound is the actual meeting of the tips of the fingers, while the adhesive plaques on the opposing surfaces of the superior surface of the dactylus and end of propodus are a suction device to increase muscular tension, and the plunger-socket is for the propulsion of a forceful jet of water. Both of the higher genera, and, to a lesser degree, the lower genera, have short stalked compound eyes covered by a forward extension of their carapace; this characteristic, however, is of little use in the field, for in life the extension is transparent and the eyes are fully visible. The species are usually small in size, seldom exceeding 20 to 30 mm in length; many are only 5 mm long when mature.

Sexual dimorphism or even polymorphism is found in the family. Almost all of the species in the various genera of the family show the development of some secondary sexual characteristics, the most consistent of which is the presence on the males of two lobes (the *appendix interna* and the *appendix masculina*) on the medial side on the endopod of the second pleopods, in contrast to the *appendix interna* alone in the females. Other sexually dimorphic traits may be the pleura of the abdomen, the size of the abdomen itself, and the form of the large chela; the dimorphism is so pronounced that Coutière, the leading worker on the group in the early 1900's, described a male and a female of the same species as two separate species in separate subgeneric groups of *Alpheus*.

However, Suzuki (1970) studied carefully four species of the genus *Athanas*, especially *A. kominatoensis* Kubo, and found the species to show protandrous consecutive hermaphroditism. He found the youngest sexually mature forms to be functional males, those of intermediate sizes to be functional females, and the largest sizes again to be functional males; histological studies of the paired gonads showed that at all times both testicular and ovarian tissue could be found. With this partial alternation of sex there was confusion of characteristics previously thought to be dimorphic with the sex, especially in the form of the large chela and even in the *appendix masculina*, with some ovigerous females bearing the supposedly unique male structure.

Suzuki's work was confined to four species of *Athanas*, but his conclusions probably can be extended to other species, and possibly to other genera, explaining problems that have long perplexed the workers on the group. Thus, our questions about the forms of the chelae in our review of the genus *Athanas* (1960a) as well as Kemp's (1915) concern about the multiple forms of his species, *A. polymorphus*, can probably be answered by Suzuki's studies. Miyake & Miya (1967) have reported that an ovigerous *Aretopsis amabilis* De Man from the Ryukyu Islands had the *appendix masculina* developed, so this species, too, may undergo a similar change in sex. Finally, as discussed in this paper, the sex of the members of *Automate* cannot be distinguished by external characters unless they are ovigerous, and this also may be the reflection of physiological changes in the sex of the individuals. To date, there is no evidence of sexual ambiguity in the higher genera.

Finally, some species are remarkably constant in their development, so that even such a minor characteristic as the angle of the margins of a groove on the large chela is constant amongst specimens collected as far apart as Hawaii, the Red Sea, and Australia. However, others, as those collected from the spongocoel of a single sponge or single living head of coral, exhibit wide variation in most parts considered to be of taxonomic value.

General Distribution and Ecology

The alpheids are characteristically associated with the complex of tropical coral reefs, from the inshore beaches across the growing reefs to the offshore muddy bottoms. There appears to be a greater penetration of the family into temperate waters in Australia than in the Northern Hemisphere. The members of the family may penetrate through brackish estuaries into fresh waters. The two cavernicolous species of *Metabetaeus*, known only from islands of the Central Pacific, appear in isolated brackish water pools which are largely fresh at time of high rainfall. Two species of *Alpheopsis* have been reported from fresh water in Western Africa. *Alpheus heterochaelis* Say is reported from fresh water in lakes of southern Florida (Kingsley, 1878; Hendrix, 1971). Johnson (1965: 9) has reported *Alpheus paludicola* Kemp (as *A. paludosus*) in "fresh water above the limit of tidal influence in the Sedili basin of South Johore" in Malaya. Probably the highest penetration through an estuary into fresh water in this region is that of *Alpheus microrhynchus* De Man in the Chaophya River system to at least the canals ("klongs") of Bangkok, Thailand, 15 miles from the river mouth and certainly completely fresh water during the rainy season; it was reported there by De Man (1898: 318) and Banner and Banner (1966b: 133). In Australia we have records of the genus *Alpheus* reaching up various rivers, for example up the Swan River to Perth, in Western Australia, and rivers in New South Wales and Queensland, but these are evidently brackish waters. While the habitats are undoubtedly washed with fresh water at time of heavy rain, we have no records of further penetration by alpheids into strictly fresh water in Australia.

In the coral reef complex, however, they reach their maximal development, and there they probably are the most common family of the decapod crustaceans, both in number of species and in number of individuals. A few species live in the open in their habitats, as in tide pools, or free in algal mats. However, most species are cryptic, living hidden to some degree. A few species live between the fronds of living coral; one species makes fissures on the surface of living heads. Some construct tubes of living algae, others live in galleries constructed under sheets of calcareous algae (*Porolithon*). Most species either live in tunnels or cavities in dead coral, especially dead and overgrown heads, or burrow into the substrate; of the latter, some burrow under boulders, and others dig directly into the sand or silt bottoms. A number are associated in varying degrees of symbiotic relationship with other animals, such as molluscs, crinoids, and especially sponges; in none has the degree of mutualism-parasitism been determined, and in some cases the species are not obligate symbionts.

The role of the alpheids in reef ecology has been inadequately studied. Bowers found the species he studied, *Alpheus clypeatus* Coutière, to be entirely herbivorous in habit, eating the growing algae incorporated into its tube. We have observed other species which appear to be either omnivores or carnivores. The capture of food from their sequestered habitats is not understood, but some authors suggest that they stand at the front of their openings and stun prey by the forceful jet of water from the piston-cylinder arrangement of the large chela. Alpheids, of course, constitute a normal food for larger carnivores when they can be captured.

Support and Acknowledgments

Our studies at the University of Hawaii and in Australia were supported by U.S. National Science Foundation grants GB 3804, GB 6386, and GB 25020. The Great Barrier Reef Committee extended to us the use of the Heron Island field station, and Mr G. G. T. Harrison, Chief Fisheries Officer, Fisheries Section, Queensland, issued a permit to allow us to collect specimens along the Queensland coast.

We wish to thank the following Australian institutions for the loan of specimens for our study:

Aquinas College, Manning, Western Australia; Australian Museum, Sydney, New South Wales; James Cook University, Townsville, Queensland; Macleay Museum, University of Sydney, New South Wales; National Museum of Victoria, Melbourne, Victoria; Queensland Museum, Brisbane, Queensland; Queen Victoria Museum and Art Gallery, Launceston, Tasmania; South Australian Museum, Adelaide, South Australia; Tasmanian Museum and Art Gallery, Hobart, Tasmania; University of Queensland, Brisbane, Queensland; Western Australian Museum, Perth, Western Australia.

The following museums not in Australia graciously lent collections and individual specimens upon request:

Allan Hancock Foundation, Los Angeles, California; Muséum National d'Histoire Naturelle, Paris; Smithsonian Institution, Washington D.C.; Rijksmuseum van Natuurlijke Historie, Leiden; Zoologisch Museum, Universiteit van Amsterdam; Musée Zoologique, Strasbourg.

In addition we wish to thank the following for the loan of specimens and for the assistance they gave us:

John Boase, Fannie Bay, Darwin, Northern Territory; A. J. Bruce, Mombasa, Kenya; Jacques Forest, Muséum National d'Histoire Naturelle, Paris; L. B. Holthuis, Rijksmuseum van Natuurlijke Historie, Leiden; Yasuhika Miya, Kyushu University, Fukuoka, Japan; C. R. Smalley, University of Western Australia, Perth, W.A.

Above all, we would like to extend our deep appreciation to Dr John Yaldwyn, formerly with the Australian Museum and now at the Dominion Museum in Wellington, New Zealand, who suggested this monograph, helped us arrange for the loan of specimens from museums, and advised us on our field studies in Australia.

Locality Lists

The full collection notes and explanation of the alpha-numerical code used in the text to designate individual collections is given in the appendix.

Family **ALPHEIDAE** Rafinesque

Carapace smooth, provided with cardiac grooves; rostrum reduced, antennal and branchiostegal spines always absent; in most genera the eyes, or their bases only, are covered by an anterior projection of the carapace. Antennular base cylindrical, with the basal article not longer than sum of other two; scaphocerite rarely longer than peduncles. Mandible always bipartite with palpus of two articles, except in *Prionalpheus*. Distal article of maxillule bifurcate at its extremity except in *Prionalpheus*. Epipodites of first and second maxillipeds always undivided. Chelae of the first thoracic legs, when fully developed, always larger than other legs, usually of massive and asymmetrical development. Carpus of chelipeds usually short, cup-shaped, or hemispherical. Second legs chelate, with chela weakly developed and carpus of three to five articles. Following legs short, compressed, with spinous propodi and dactyli with one to three ungui. Propodus of fifth leg with more or less well-developed "brush" of bristles placed in transverse-oblique rows. Abdomen usually with gradual curve, without any pronounced bending at third segment; sixth segment broad and short; size and shape of pleura usually showing sexual dimorphism. The branchial formula always includes five pleurobranchs.

Key to the Genera of Alpheidae in Australian Waters*

1. Cornea of eye fully exposed in dorsal and lateral view except for anterior teeth of carapace 2

— Cornea of eye concealed in dorsal view and partially to completely concealed in lateral view by anterior extension of carapace 4

2. (1) Cornea only exposed, normally developed, rostrum well-developed, reaching beyond eyes 3

— Cornea and peduncle exposed in dorsal view, cornea somewhat degenerate; rostrum vestigial, not reaching far on peduncle...... .... *Automate* (p. 299)

3. (2) Dactylus of large chela usually carried in lateral position; rostrum long and, in lateral view, acute .... *Athanas* (p. 303)

— Dactylus of large chela always carried in inferior position; rostrum short and, in lateral view, rounded .... *Aretopsis* (p. 330)

4. (1) Large chela carried flexed at carpus, fitting precisely into merus; tip of telson notched .... *Salmoneus* (p. 334)

— Large chela carried extended; tip of telson convex 5

5. (4) Fingers of large chela with serrations of fine to heavy teeth, never with a plunger and socket 6

— Fingers of large chela without serrations or teeth, with a strong plunger on dactylus that fits into socket on base of propodal finger (in some species the device is reduced to a heavy crest and a propodal groove) 7

---

* To prevent added confusion in this difficult family, we have limited the key to those genera known to Australian waters. If a species is found that does not fit the key, the reader is referred to Holthuis' key to the family (1955: 83), which includes eight genera not known from Australia. In the use of Holthuis' key, however, it should be recalled that the genus *Arete* has been placed in synonymy (Banner & Banner, 1960: 135) and that the Pacific species of *Thunor* are placed in the genus *Alpheus* (Banner & Banner, 1966a) but the genus is retained for the Atlantic species (Chace, 1972: 104). Since the publication of Holthuis' key, three new genera have been added (*Prionalpheus* Banner & Banner 1960, *Leptalpheus* Williams 1965, *Betaeopsis* Yaldwyn 1971) and the genus *Metalpheus* Coutière 1908 has been revived by Chace (1972).

6. (5) Rostrum present of various development; dactylus of large chela carried in superior or lateral position . . . . *Alpheopsis** (p. 336)
— Rostrum completely lacking and extended front of carapace rounded in dorsal view; dactylus of large chela carried in inferior position . . . . *Betaeus* (p. 347)
7. (5) Body highly compressed; carapace with knife-like mid-dorsal keel for its entire length . . . . *Racilius* (p. 350)
— Body not markedly compressed; if carapace bearing a keel, keel not knife-like posteriorly 8
8. (7) With pterygostomial margin produced into a definite angle; without anal tubercles; without mastigobranchs and setobranchs . . . . *Synalpheus* (pt 2)
— With pterygostomial margin rounded, never angular; with anal tubercles; bearing mastigobranchs and setobranchs at least on anterior thoracic legs . . . . *Alpheus* (pt 3)

Genus **AUTOMATE**

Automate De Man, 1888a, Arch. Naturgesch. 53 (1): 529.

Type Species: Automate dolichognatha De Man.

Definition: Carapace laterally compressed, rostrum if present only slight, without orbital teeth. Eyes not covered by carapace, free with reduced corneas.

Antennular peduncles extremely elongate with second article frequently the longest. Stylocerite reduced, scaphocerite reduced, carpocerite elongate. Third maxilliped longer than antennular peduncles.

Chelipeds carried extended, asymmetrical and sexually dimorphic, compressed, with surfaces smooth and without sculpture; dactyls without cylinder and plunger characteristic of *Alpheus*.

Second legs with five articles in carpus. Following thoracic legs unarmed, with simple dactyl.

Pleura of sixth abdominal somite not articulated. Telson of normal form, without anal tubercles.

Branchial formula: 5 pleurobranchs, 1 arthrobranch, and 8 epipodites.

Automate dolichognatha De Man

Automate dolichognatha De Man, 1888a, Arch. Naturgesch. 53 (1): 529, pl. 22, fig. 5. Lanchester, 1901, Proc. Zool. Soc. Lond. 2 (1): 564, pl. 34, fig. 3. Coutière, 1903, Bull. Soc. Philomath. Paris IX, 5 (2): 74, fig. 8.

Automate gardineri Coutière, 1902, Bull. Mus. Hist. Nat., Paris 8 (5): 337; 1903, Bull. Soc. Philomath. Paris IX, 5 (2): 72, figs 1–7; 1905a, Fauna Geog. Mald. Laccad. 2 (4): 854, figs 127, 128 [same as 1903]. Holthuis, 1958, Bull. Sea Fish. Res. Stn., Israel, Bull. 17 (8): 17, fig. 6. Miyake & Miya, 1966, J. Fac. Agric. Kyushu Univ. 14 (1): 137, fig. 2. Banner & Banner, 1966b, Siam Soc. Monogr. (3): 37, fig. 8.

---

* Under this dichotomy also falls *Batella* Holthuis (= *Cheirothrix* Bate, 1888), described on the basis of a single specimen from Cape York. It can be distinguished from *Alpheopsis* principally by the lack of a mandibular palp, extremely small and hairy fingers on the chelae of the second legs, and the lack of articulated pleura on the sixth abdominal segment. It will be discussed in Part III of this paper.

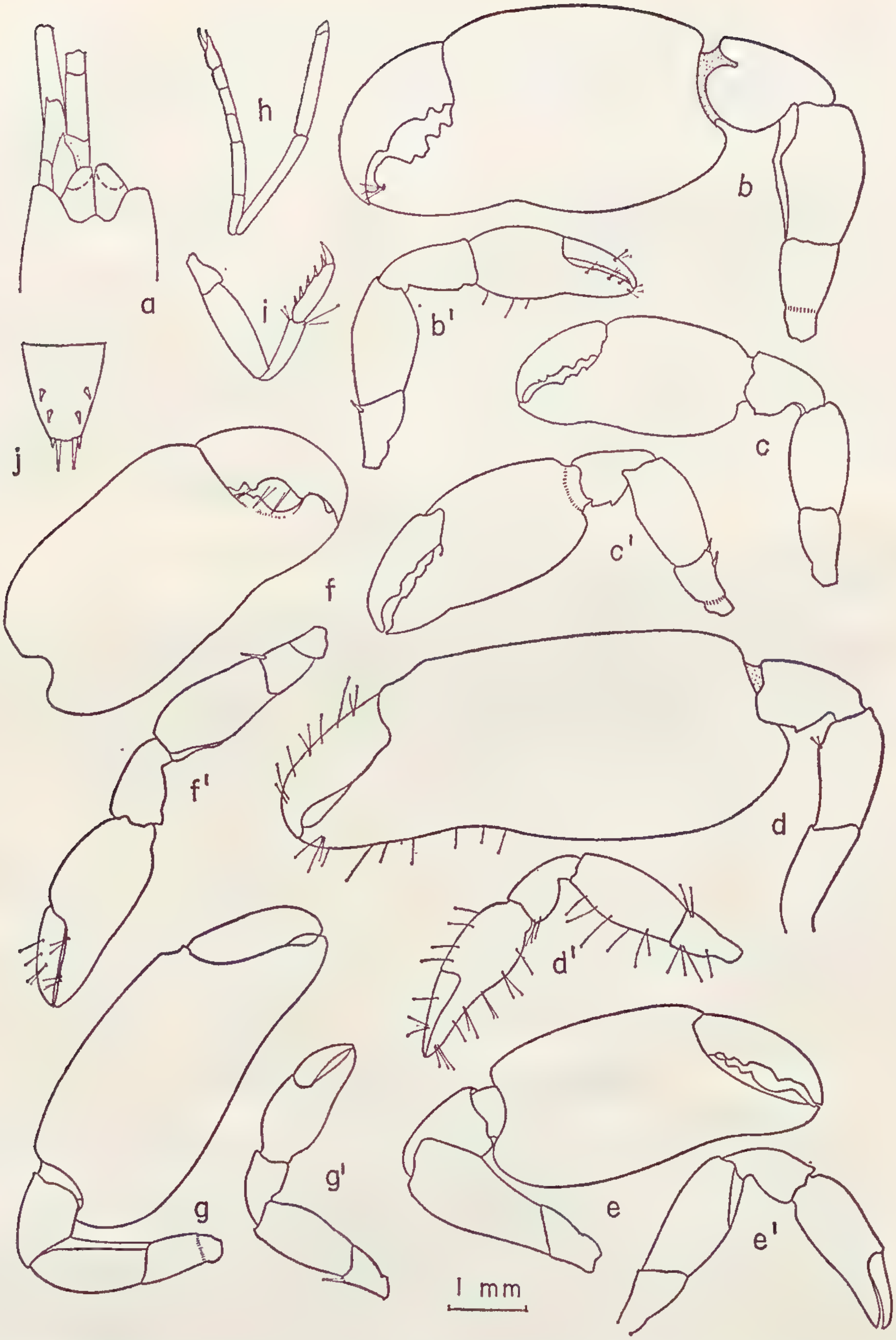


Figure 1.—*Automate dolichognatha* De Man. a, anterior region of 17 mm ovigerous female from BAU 46, dorsal view; b, b′, large and small cheliped of fig. a; c, c′, large and small cheliped of 15 mm ovigerous female from BAU 46; d, d′, large and small cheliped of 17 mm ovigerous female from BAU 36; e, e′, large and small cheliped of 18 mm female from Mirs Bay, Hong Kong; f, f′, large and small cheliped of 10 mm ovigerous female from US 123609; g, g′, large and small cheliped of 12 mm ovigerous female from BAU 46; h, second leg of figure a; i, third leg of figure a; j, telson of figure a.

Automate sp. De Man, 1911, Siboga Exped. 39a^1 (2): 140, fig. 2.

Automate johnsoni Chace, 1955, Proc. U.S. Natn. Mus. 105 (3349): 13, fig. 7.

Specimens examined: 1 specimen from AM P.8677; 3, BAU 36; 5, BAU 46; 3, US 123609.

Diagnosis: Central section of anterodorsal margin of carapace recessed above eyestalks, leaving them exposed to near base. Rostrum small, rounded, at times triangular, not reaching to near level of frontal margin of carapace. Eyestalks flattened medially, convex laterally with poorly developed corneal area occupying only a small portion of distolateral surface. Second antennular article about 2.5 times as long as portion of first beyond eyestalks, varying from 2.5 to 4.0 times as long as broad. Third article 0.3 as long as second. Stylocerite reaching to near end of first antennular article. Scaphocerite reaching variously from 0.5 to 0.8 length of second antennular article; squamous portion shorter than lateral spine. Carpocerite from equal to, to slightly longer than, antennular peduncle. Spine of basicerite small.

Third maxillipeds much longer and stouter than antennular peduncles, reaching almost the length of the antennular articles.

Large chela compressed, varying from 1.8–2.4 times as long as broad. Contours of chela, viewed laterally, variable due to differing development of rounded constriction in lower margin proximal to dactylar articulation. Dentition on cutting surfaces of dactylus and fixed finger various (see figs 1b–g), not correlated with size or sex. Merus swollen in the middle, varying from 1.6–2.6 times as long as broad. Small cheliped about half as long as large cheliped. Chela 2.5 times as long as broad, palm and fingers subequal. Carpus similar to that of large chela. Merus over 2 times as long as broad. Ischium as long as carpus, slender, bearing one or 2 strong stiff setae or spines on superodistal margin.

Carpal article of second legs with the ratio: 10 : 12 : 7 : 6 : 7.

Merus of third leg 3.4 times as long as broad. Carpus 0.6 as long as merus. Propodus nearly equal to carpus, bearing 5 spinules on inferior margin; dactylus simple.

Telson shorter than uropods, 3.0 times as long as broad at its posterior margin. Lateral margins slightly curved. Inner spines of posterior pair unusually long, outer spines short, as long as spines on upper surface of telson.

Discussion: De Man's original description was based on a single male specimen from Noordwachter, "Indian Archipelago" (=Indonesia?), from which the chelipeds were lacking. In 1901 Lanchester described the chelipeds of a specimen of *A. dolichognatha* from Penang. However, in his figures he did not depict the complete meri of the chelipeds, nor did he state the length-breadth ratio of that article.

Coutière established *A. gardineri* in 1903 on three differences that he considered to separate it from *A. dolichognatha*: (1) a ratio of less than 2 for the length : breadth ratio of the large chela in contrast to a ratio of more than 2 for *A. dolichognatha*; (2) a ratio of 1.38–1.5 for the length : breadth ratio in the merus of the large cheliped in *A. gardineri*, in contrast to 1.6–2.0 in *A. dolichognatha*; (3) the proportion in the carpus of the second leg wherein his specimens had 3rd and 5th article equal with 4th a little shorter, in contrast to having the 4th and 5th equal with the 3rd a little shorter in *A. dolichognatha*.

In the first place, it is difficult to reconcile Coutière's statements with the previous descriptions and with his own specimens. As indicated, until Coutière stated the proportions of the cheliped they had not been mentioned in the literature. It is true that Lanchester's figures of the chelae of *A. dolichognatha* were published in 1901, but he did not publish measurements; moreover, Coutière was apparently unaware of Lanchester's work as nowhere does he mention it. Coutière (1903: 74) states of the large chela of the female: "le rapport de la longuer à la hauteur, pour la pince entière, est toujours inférieur à 2, alors qu'il dépasse presque toujours ce chiffre chez l'*A. dolichognatha* ♀, dont la grande pince est plus longue et moins renflée." But in his figure the ratio of the total length to width is 2.0 for the female (fig. 6) and 2.4 for the male (fig. 3). It should be noted that figures 3, 4, 4' were drawn from a detached chela and the appendage was merely presumed to have come from a male. We have examined some specimens at the National Museum of Natural History in Paris from Djibouti which Coutière had identified as *A. dolichognatha* and found that they varied from typical forms of *A. dolichognatha* to forms Coutière later separated as *A. gardineri.*

Our specimens appear to bridge the gap between the two described forms. In our 5 ovigerous female specimens the ratio of length to height in the large chela varied from 1.8–2.4. The ratio of the length to the width of the merus of the large cheliped varied from 1.6–2.4. In the carpus of the second legs the extent of variation in the carpal articles was as follows: 10 : (14–25) : (6–9) : (6–8) : (6–10). It is obvious that the slight differences in proportions that Coutière used to separate the two species were not meaningful.

We did note that in this small group of female specimens we appeared to have 2 types of chelae. The first is stout, square-shaped with large teeth on opposing surfaces of the dactyls, and the other being more slender and narrowing distally with either small or no teeth on dactyls. These 2 types of chelae are the same as those in Coutière's description (1905a: 74) which he assumes are the differences between the chela for the male and the chela for the female. We have figured the chelipeds of 6 ovigerous females (fig. 1b, b'–g, g') to show the wide variation in the chelae as well as meri and carpi. These figures rule out the criteria used by Coutière to separate the males from the females. In the genus *Automate* the second pleopod carries only the *appendix interna* in both sexes. We have found no other character by which we can separate the sexes. It may be that *Automate* is hermaphroditic, as Suzuki (1970) has pointed out for some members of the genus *Athanas.*

We feel, in view of the many contradictions between Coutière's illustrations and his stated figures, and the variations noted in our own specimens, that *A. gardineri* is a synonym of *A. dolichognatha.* We have already placed *A. johnsoni* Chace in synonymy with *A. gardineri* (1966a: 150). Holthuis (1958) pointed out that *Automate* sp. of De Man (1911) might also be referred to this species; we have placed that form in synonymy.

This leaves 3 valid species of *Automate* in the Central Pacific, *A. dolichognatha*, *A. anacanthopus* De Man and *A. salomoni* Coutière. *A. salomoni* is distinguished from the other two by the form of the acute triangular rostrum which passes the frontal margin and reaches to the last one-fourth of the eyestalks. *A. anacanthopus* is separated from the other two by having no spines on the propodi of the thoracic legs. In addition, there are 6 other presumably valid species: *A. talismani* Coutière from the Azores; *A. evermanni* Rathbun from Porto Rico; *A. kingsleyi* Hay & Shore from North Carolina; *A. rugosa* Coutière and *A. haightae* Boone from the Bay of Panama, and *A. rectifrons* Chace from the Caribbean.

Biological notes: Specimens of this species are most commonly found under rocks in the tidal zone. They are usually pale orange in colour with orange eggs. Miyake & Miya (1966: 139) note ". . . pale orange when alive, with red chromatophores distributed over the entire body. The lateral side of the carapace is dark orange. In the large cheliped the movable finger and margins of the chela are tinged with light-yellowish orange, the carpus is dark orange. Eggs are dark orange".

Australian distribution: This species has been collected off Queensland in the Capricorn and Whitsunday groups.

General distribution: This species has been reported from Djibouti, Eylath Israel, Maldive and Laccadive Archipelagoes, Malaysia, Japan. In the Central Pacific it has been collected from the Marianas Islands to as far east as Samoa.

Genus **ATHANAS**

Athanas Leach, 1814, *Edinb. Encycl.* 7 (2): 432. (Confer: Banner & Banner, 1960: 134.)

Arete Stimpson, 1861, *Proc. Acad. Nat. Sci. Philad.* 1860: 32.

Type species: Palaemon nitescens (Leach?). [According to Coutière (1899: 8), this species was originally *Cancer* (*Astacus*) *nitescens* (author undesignated), and was placed in the genus *Palaemon* by Leach on page 401 of his 1814 work, yet on page 432 he created the genus *Athanas* for the species.]

Definition: Rostrum well developed; supra-, extra- and infracorneal spines usually present with varying degrees of development; corneas of eyes exposed anteriorly and largely dorsally and laterally; chelae of the first legs well developed, either carried extended or flexed against an expanded merus, usually asymmetric and sexually dimorphic, always without the cylinder and plunger characteristic of *Alpheus*; carpus of second leg with four or five articles; dactylus of third legs simple or biunguiculate; pleura of sixth abdominal segment articulated; telson without anal tubercles, tip arcuate. Branchial formula variable.

Key to the Species of the Genus Athanas in Australian Waters

1.	Carpus of second leg with 5 articles	2
—	Carpus of second leg with 4 articles	10
2. (1)	Dactyl of third leg simple	3
—	Dactyl of third leg biunguiculate	8
3. (2)	Anterior margin of carapace bearing supracorneal teeth	4
—	Anterior margin of carapace without supracorneal teeth	5
4. (3)	Chelipeds of male carried almost straight forward; chelae cylindrical; extracorneal teeth much more prominent than infracorneal teeth; chelipeds of both male and female almost symmetrical	*A. areteformis* (p. 304)
—	Chelipeds of male carried flexed; chelae inflated, flexed against excavate merus; infracorneal teeth acute, more prominent than extracorneal teeth; male chelipeds almost symmetrical, female chelipeds asymmetrical	*A. djiboutensis* (p. 306)

5. (3) Merus of third leg more than 5 times as long as broad; propodus bearing only an occasional spine on the inferior margin.......... *A. japonicus* (p. 308)
— Merus of third leg less than 5 times as long as broad; propodus bearing many short spines on inferior margin 6*

6. (5) At least one chela of mature female enlarged ...... *A. locincertus* (p. 311)
— Neither chelae of mature female other than slender 7

7. (6) Carpus of female cheliped from as long as to almost twice length of chela .... *A. dimorphus* (p. 313)
— Carpus of female cheliped shorter than chela ...... *A. haswelli* (p. 316)

8. (2) Chelipeds carried extended .... *A. granti* (p. 316)
— Chelipeds carried flexed 9

9. (8) Palm of large chela bearing pronounced lobe on inferior margin; fingers of small chela dorsoventrally flattened .. *A. ornithorhynchus* (p. 319)
— Palm of large chela smooth, without lobes; fingers of small chela as usual, not dorsoventrally flattened .... *A. sibogae* (p. 321)

10. (1) Rostrum 1.0–1.7 times as long as broad; merus of third leg 3.0–4.0 times as long as broad; tooth on distal end of inferointernal margin of merus of third leg feeble .... *A. dorsalis* (p. 327)
— Rostrum 1.8–2.5 times as long as broad; merus of third leg 4.1–5.0 times as long as broad; tooth on distal end of inferointernal margin of merus of third leg well developed .... *A. indicus* (p. 327)

Athanas areteformis Coutière

Fig. 2

Athanas areteformis Coutière, 1903, Bull. Soc. Philomath. Paris IX, 5 (2): 79, fig. 17, 18; 1905a, Fauna Geog. Mald. Laccad. Arch. 2 (4): 860, fig. 132 [same as 1903]. Banner & Banner, 1960, Pacif. Sci. 14 (2): 138 [synonymy].

Athanas naifaroensis Coutière, 1903. Bull. Soc. Philomath. Paris IX, 5 (2): 77, figs 14–16.

Athanas erythraeus Ramadan, 1963. Bull. Fac. Sci. Egypt. Univ. 6: 13, pl. 1, fig. 1.

Athanas dubius Banner, 1956, Pacif. Sci. 10 (3): 322, fig. 2.

Specimens examined: 1 specimen from AM 43; 3, AM 305; 9, BAU 10; 1, BAU 13; 1, BAU 15; 1, BAU 30; 2, BAU 32; 2, BAU 50; 2, BAU 56; 1, BAU 58.

Diagnosis: Rostrum variable, reaching from near the end of the second antennular article to middle of third. Supracorneal teeth well developed. Extracorneal teeth prominent, reaching beyond cornea. Infracorneal teeth small, rounded or acute. First and third antennular articles equal, second article a little shorter than first and almost as wide as long. Stylocerite reaching just past end of second antennular article. Scaphocerite reaching slightly past end of antennular peduncle. Carpocerite reaching middle of third antennular article. Well-developed spine on basicerite.

---

*We know nothing of the third legs of *A. haswelli*, but as Coutière described it as resembling both *A. dimorphus* and *A. minikoensis*, we assume the third legs are similar.

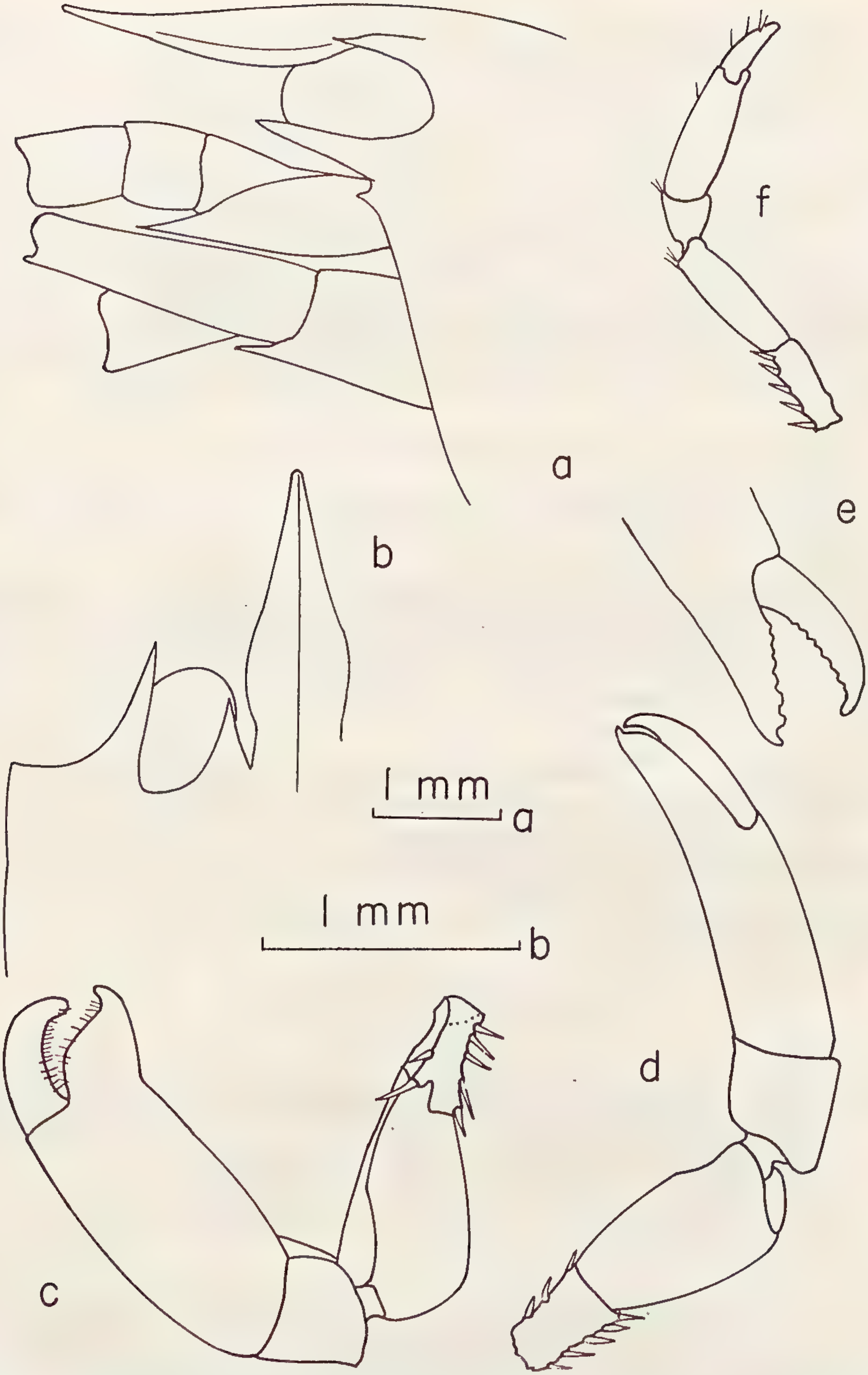


Figure 2.—*Athanas areteformis* Coutière. a, b, anterior region of 10 mm male from BAU 10, lateral and dorsal view; c, large cheliped, male, inner face; d, small cheliped, male; e, detail of fingers of small chela; f, large cheliped of 9 mm female from BAU 10. c, d, f, scale a; a, b, e, scale b.

Chelipeds sexually dimorphic and nearly symmetrical. Chelipeds not flexed, but carried directed forward. Large male chela heavy, cylindrical in form, slightly over twice as long as broad. Fingers, when viewed from the inner face, short, curved, 0.3 as long as palm; fixed finger with broad, rounded projection on cutting surface that fits into cavity on dactyl. Cutting surfaces often bearing short, stiff setae. Small chela a little more slender, cutting surfaces of fingers bearing irregular teeth that mesh when dactyl is closed. Carpus 0.3 as long as merus, rounded with distal end encompassing the base of palm. Merus, measured near the distal end, 2.2 times as long as broad, broader at distal end. Ischium as long as carpus, bearing on its superior margin 5–7 strong spines. Female chelae smaller, more slender, cylindrical, 2.5 times as long as broad with fingers occupying 0.6 the total length. Cutting surfaces of fingers bearing many short stiff setae. Carpus cup-shaped, distal end fitting over base of palm. Merus 3.7 times as long as broad. Ischium almost as long as merus, bearing movable spines on its superior margin similar to large cheliped.

Carpal articles of second leg with a ratio of 10 : 3 : 3 : 3 : 4.

Third leg much larger than second leg, merus 5 times as long as broad. Carpus 0.5 as long as merus, almost the same length as the ischium; propodus equal to merus; dactylus simple.

Discussion: Variations in the diagnostic characters of this species were discussed in a revision of the genus *Athanas* (Banner & Banner, 1960: 138). The Australian specimens show the same variations. The species is easily recognized by the well-developed supracorneal teeth combined with the forward directed chelipeds. *Athanas djiboutensis* also bears supracorneal teeth, but the chelae are carried flexed into an excavate merus.

Biological notes: The specimens were collected only in dead coral heads. This is a small species, our largest specimen being only 10 mm in length.*

Australian distribution: Seventeen of the 19 specimens were collected on coral reefs off the Queensland coast, the remaining two in the Torres Strait region.

General distribution: South Africa, Red Sea, Philippines, Marshall, Fiji, Tonga, Samoa, and Society Islands.

Athanas djiboutensis Coutière

Fig. 3

Athanas djiboutensis Coutière, 1897a, Bull. Mus. Hist. Nat., Paris, 3 (6): 233; 1905a, Fauna Geog. Mald. Laccad. 2 (4): 856, fig. 129. Banner & Banner, 1960, Pacif. Sci. 14 (2): 140, Table 1. Miya & Miyake, 1968, Publ. Amakusa Mar. Biol. Lab. 1 (2): 131, fig. 1 [see for bibliography].

Athanas sulcatipes Borradaile, 1898, Proc. Zool. Soc. Lond. 1898: 1011, pl. 65, fig. 9.

Previous Australian records:

Gurney, 1938, Sci. Rep. Gt. Barrier Reef Exped. 6: 54, figs 249–252 [larval forms].

Specimens examined: 5 specimens from AM 74; 8, AM 109; 2, AM 123; 2, BAU 50.

---

*In this study the "length of specimens" is always the total length from rostrum to tip of telson unless carapace length is specified.

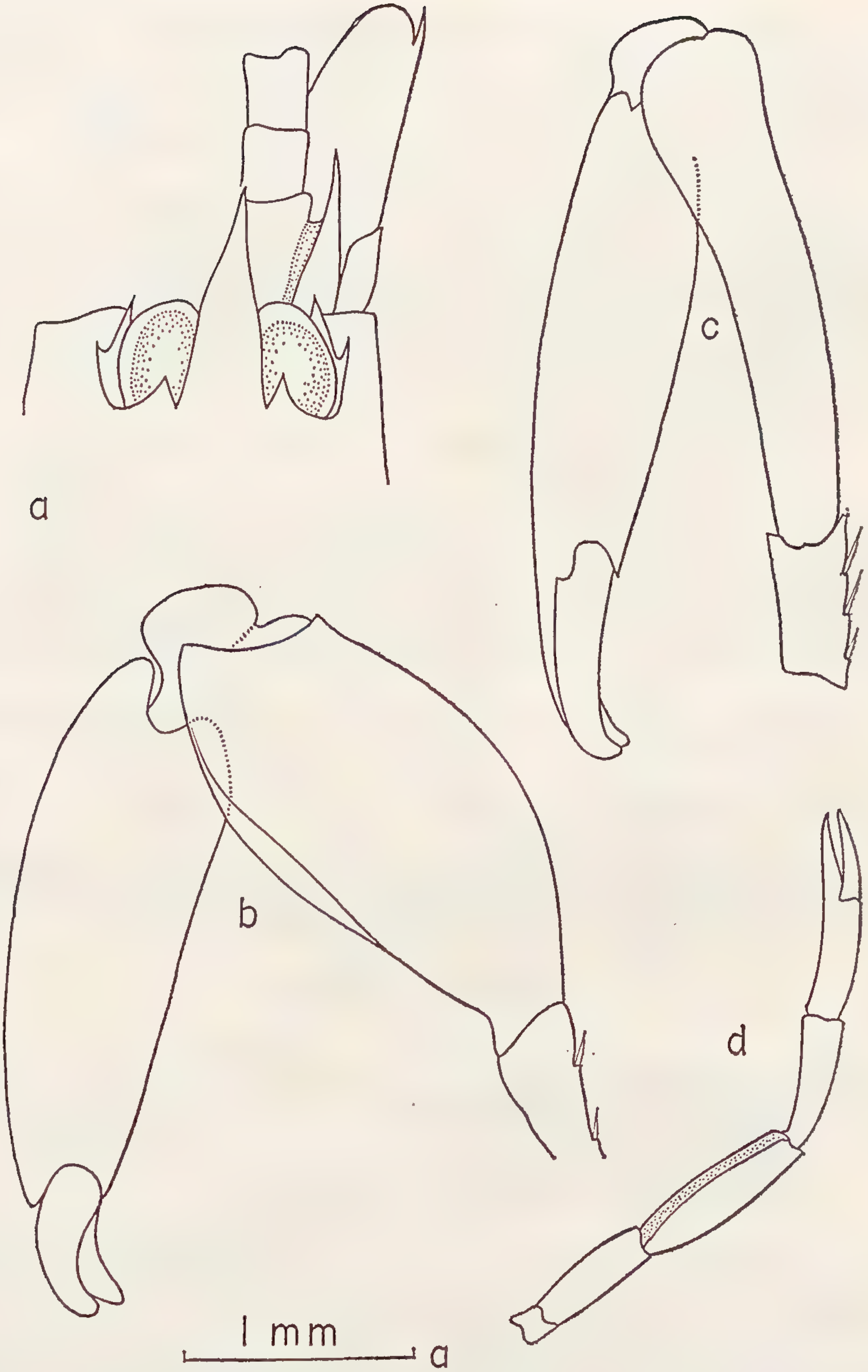


Figure 3.—*Athanas djiboutensis* Coutière. a, anterior region of 11 mm male from AM 74, dorsal view; b, large cheliped of male; c, large cheliped of 10 mm female from AM 109; d, small cheliped of same female.

Diagnosis: Rostrum variable, reaching from past end of first antennular article to proximal third of third antennular article. Supra-, extra- and infracorneal teeth present and acute. First article of antennular peduncle almost twice length of second; second and third articles subequal. Stylocerite reaching middle of second antennular article. Scaphocerite reaching well beyond antennular peduncles, carpocerite reaching just past end of second antennular article.

Chelipeds of male nearly symmetrical. Palm and merus almost equal in length, both heavy. Palm round, merus excavated to accommodate palm when flexed. Fingers only one-quarter length of palm. Carpus short and bulbous. Ischium bearing 2–3 spines on superior margin. Female chelipeds asymmetrical. Large chela similar to that of male in proportions but more slender. Inner face of merus excavated to accommodate palm when flexed. Ischium bearing 3 spines. Small cheliped of female less than one quarter as long as large cheliped. Merus 4 times as long as wide. Ischium 0.6 as long as merus. Carpus slender, 0.7 as long as merus. Chela as long as merus.

Second and third legs similar to those of *A. areteformis.*

Discussion: Athanas djiboutensis is widespread and has often been discussed and figured in the literature. The most perplexing thing about this species is the variation in the chelipeds. We analyzed the chelipeds of 24 specimens, both male and female, and have presented our findings in tabulated form (1960: 140). Tattersall (1921: 368) implies that possibly *A. djiboutensis* becomes sexually mature before it is fully grown. It is likely there may be consecutive hermaphroditism here similar to that reported upon by Suzuki (1970: 15) for some other members of this genus.

Biological notes: This species has been collected intertidally under rocks as well as in heads of dead coral.

Australian distribution: This species has only been collected at Heron Island and some islets in the Coral Sea.

General distribution: Israel, Red Sea, South Africa, Maldive and Laccadive Arch., Indonesia, Japan. In the Central Pacific it has been collected in the Marshall, Ellice, Fiji, Tonga, Samoa, Phoenix, Society and Marquesas Islands.

Athanas japonicus Kubo

Fig. 4

Athanas japonicus Kubo, 1936, J. Imp. Fish. Inst., Tokyo 31 (2): 43, pl. 13. Miya Miyake, 1968, Publ. Amakusa Mar. Biol. Lab. 1 (2): 139, figs 4–6.

Athanas lamellifer Kubo, 1940, Annotnes Zool. jap. 19 (2): 102, figs 3–5.

Specimens examined: 1, 10 mm female from BAU 75.

Diagnosis: Rostrum thin, reaching to end of second antennular article. Rostral carina slight, extending to just beyond orbits. Extra- and infracorneal teeth present and acute, reaching almost to middle of cornea; infracorneal tooth slightly longer than extracorneal. First and second antennular article equal, third a little shorter. Second article longer than broad. Stylocerite reaching past end of second antennular article. Lateral spine of scaphocerite as long as antennular peduncle, squamous portion a little longer. Carpocerite reaching to end of second antennular article. Lateral tooth of basicerite acute.

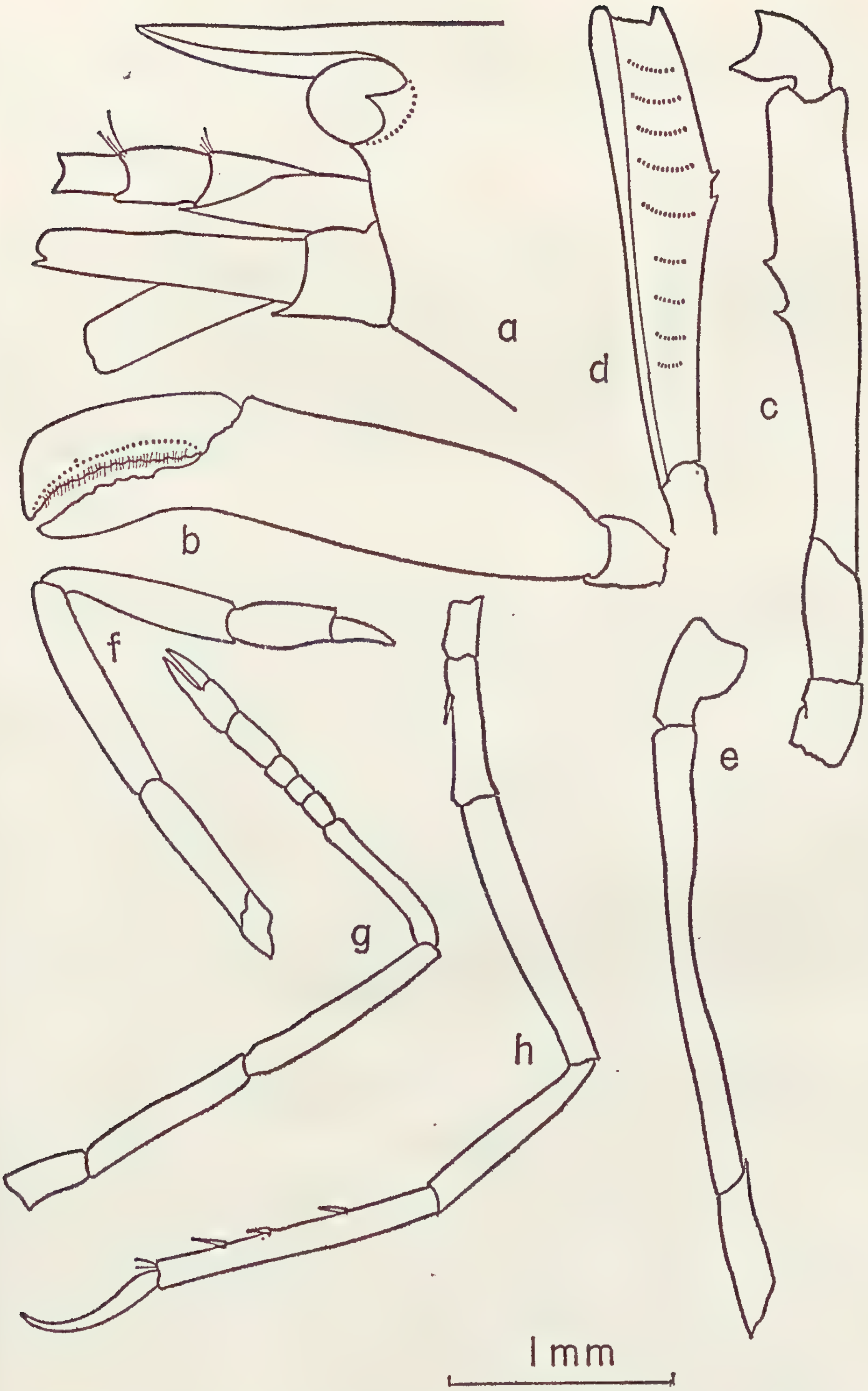


Figure 4.—*Athanas japonicus* Kubo. a, anterior region of 11 mm female from BAU 75, lateral view; b, large chela; c, d, e, merus of large chela, inferior, superior and internal aspect; f, small cheliped; g, second leg; h, third leg.

Large chela slender, 5 times as long as broad, with fingers occupying distal 0.3. Dactylus with knife-like ridge on superior surface; inner side of dactylus flattened, outer a little convex. Cutting surface with fringe of closely-set setae; cutting surface of fixed finger bearing row of irregular teeth. Carpus cup-shaped. Merus elongate, slender, 5 times as long as maximum breadth, excavated to accommodate chela when flexed; superior and inferointernal margins rounded, inferoexternal margin produced and knife-like, bearing 2 dentate projections; distal tooth larger than proximal.

Small cheliped of the *dimorphus* type, with chela about one-quarter the length of large chela. Carpus 0.8 length of merus, subequal to ischium and to chela; fingers 0.7 length of palm.

Ratio of articles of second leg 10 : 1.7 : 1.5 : 1.4 : 4.

Third leg with merus 7 times as long as broad. Ischium 0.5 as long as merus, bearing on its superior margin one movable spine. Carpus 0.7 length of merus; propodus thin, equal to length of merus, bearing 2 spines on inferior surface and a pair distally. Dactylus one-half as long as propodus, thin, curved and acute.

Telson 4 times as long as wide at posterior margin. Posterior margin slightly arcuate.

Discussion: Miya and Miyake (1968: 139) with a collection of 38 specimens of *A. japonicus* reviewed the range of variation for this species. The rostra varied from just beyond the end of the first antennular article to the end of the third. "In the majority of the specimens the infracorneal tooth is well developed, but in varying degree, and longer than the extracorneal one, while in the rest the infracorneal tooth is as long as, or shorter than, the extracorneal one." The second antennular article varied from 0.7–2.5 times as long as broad. The stylocerite varied from reaching the proximal third of the second antennular article to the proximal half of the third article. The chelipeds varied considerably in the arrangement and shape of the teeth on the cutting edge of the fingers, and the teeth on the inferointernal margin of the merus varied from one to several. The chelipeds varied in development only roughly with size and sex with the smaller females and some males bearing symmetrical small chelipeds like our figure 4f, larger females and smaller males with symmetrical chelipeds as described above, and the largest males with almost symmetrical large chelipeds like our figure 4b. The chelae also varied markedly in the teeth of the cutting edges, and the merus in the teeth along the lamellar margin. This type of variation is not uncommon in the genus *Athanas*.

Biological notes: Our specimen was collected from a muddy foreshore interspersed with rock and mangrove roots near the pier at Darwin, N.T. It is interesting to note that Miya and Miyake's specimens were also taken from a muddy environment. Miya and Miyake report the ground colour in life is "bluish purple . . . with scattered red chromatophores. The eggs are green". On this ground-colour is a line or varying series of broken patches of pale yellow or no pigment along the midline of carapace and abdomen, often with smaller patches laterally, especially on the abdomen. The tips of the outer uropods and at least the tip of the telson bear similar patches. Miya and Miyake also noted that *A. japonicus* usually keeps the chelipeds folded beneath the body when walking, but when approached by another specimen they extended their chelae in a threatening fashion.

Australian distribution: This specimen came from Darwin, N.T. It is the first time this species has been reported from Australia.

General distribution: This species has previously been reported only from Japan.

Athanas locincertus sp. nov.

Fig. 5

Holotype: 10 mm male from Panchoran Buoy [Western Australia?] WM 61–65. Coll. 13/7/61.

Allotype: 11 mm female from same location.

Diagnosis: Rostrum reaching to near end of second antennular peduncle. Eyes almost entirely exposed. Supracorneal spine absent; extracorneal spine acute and reaching about half the length of cornea, infracorneal spine also acute and a little longer. Antennular articles subequal, second article a little longer than wide. Pterygostomial angle obtuse, not projecting. Stylocerite reaching to near end of second antennular article. Scaphocerite when viewed dorsally reaching just past end of antennular peduncle, lateral spine a little longer than squamous portion. Carpocerite reaching almost to end of antennular peduncle. Lateral spine of basicerite acute.

Male chelipeds without marked asymmetry. Basis bearing single spine; ischium short, bearing 3 spines. Merus inflated, 2.4 times as long as wide in the middle; inferior surface deeply excavate to accommodate palm. Carpus short, cup-shaped. Chela inflated, 3 times as long as broad, 1.3 times length of merus, dactyls occupying distal quarter. Cutting surface of fixed finger abruptly bent distally toward both medial and inferior plane; with proximal half smooth and without teeth; with a heavy flattened tooth proximal to bend, and a few small irregular teeth distally; tip curved and acute (not shown in figures because of angle). Dactylus crossing fixed finger on its smooth proximal half so that the heavy tooth of the fixed finger lies on inner surface, and acute tip of dactylus lies outside of fixed finger; dactylus with small serrate teeth proximal to tip where it contacts fixed finger. Small male cheliped similar to large, but smaller and more slender. Chela itself almost 0.7 length of large chela, over 4.5 times as long as broad; fingers slender, bearing on their cutting surfaces serrated teeth that intermesh when fingers are closed. Serrated edges interspersed with short stiff setae. Female with one cheliped missing. Basis and ischium bearing 7 spines of moderate development. Merus excavated but not markedly inflated. Ratio of lengths of articles of cheliped : ischium, 10: merus, 35: carpus, 7: palm, 34: fingers, 15. Both fingers slightly curved and bearing on outer face in distal two-thirds serrated teeth that intermesh when closed, upper teeth interspersed with short setae; tips crossing when closed. Dactylus bearing on outer face of cutting surface a short but dense fringe of setae that obscures from view the teeth on the inner side.

Ratio of carpal articles of second leg: 10 : 1.8 : 1.8 : 1.8 : 4.0.

Ischium of third leg unarmed. Merus 4 times as long as broad, without spine. Carpus 0.5 as long as merus, superior margin extending as a blunt tooth. Propodus slender, a little longer than merus, bearing on its inferior margin 8 short movable spinules and 2 distally. Dactylus robust, curved, simple, 0.3 as long as propodus. [Description of allotype; holotype too fragmentary.]

Telson 2.7 times as long as posterior margin is broad. Anterior margin 1.6 times wider than posterior.

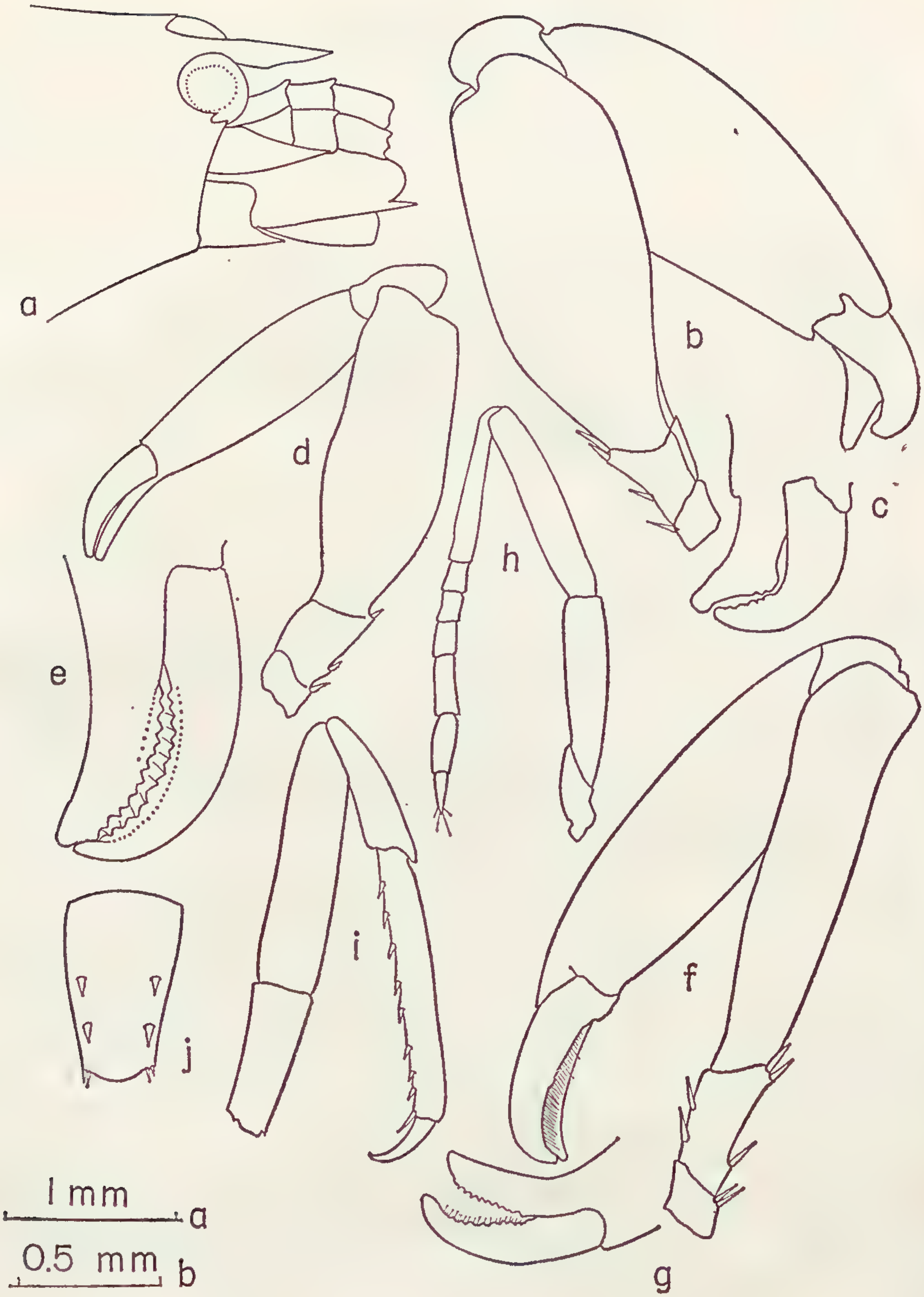


Figure 5.—*Athanas locincertus* sp. nov. a, anterior region of holotype, lateral view; b, large cheliped; c, detail of fingers of large cheliped; d, small cheliped, inner face; e, detail of fingers of small chela; f, small cheliped of allotype, outer face; g, detail of fingers of fig. 5f, inner face; h, second leg of allotype; i, third leg of allotype; j, telson. All figures but e scale a; e, scale b.

Discussion: These specimens are most closely related to *A. japonicus* Kubo because of the presence of an infracorneal tooth; the development of the chelae, especially that of the female, falls well within the range of variation given for *A. japonicus* by Miya & Miyake (1968). However, the extreme twist of the fingers of the large chela of the male and the fringe of closely set setae on the inner face of the dactylus of the small chela is different from *A. japonicus* and apparently unique to the genus. This species also lacks the lamellar extension of the merus and the teeth on its margin so characteristic of *A. japonicus*. There are also marked differences in the third legs: in *A. japonicus* the merus is 7 times as long as broad, in this species but 4 times; in *A. japonicus* the propodus bears few spines, while in this species they are numerous; in *A. japonicus* the dactyl is slender and 0.6 as long as propodus, while here it is heavy and 0.3 the length of the propodus. This species differs from *A. dimorphus*, in which neither the chelipeds of the female have the inflated palm and merus, nor the very short carpus.

Unfortunately, we cannot give the type locality for this species. The specimens were lent by the Western Australian Museum, and the label carried only "Panchoran Buoy", without a collector's name. The Western Australian Museum could not find a buoy by that name in any gazeteer or sailing directions for any part of Australia; we requested the Honolulu office of the U.S. Hydrographic Office to search its references, but they could find nothing. We can only suggest that perhaps the name is mis-spelled, or that it might be in Indonesian waters where somewhat similar phonetics may be found. All we may presume is that the buoy is some place that can be reached by sailing from Fremantle or other Western Australian ports, and that it lies in the tropics or subtropics.

The name given reflects this lack of specific locality, as it is derived from *locus incertus*. The type and allotype will be deposited at the Western Australian Museum.

Athanas dimorphus Ortmann

Fig. 6

Athanas dimorphus Ortmann, 1894, Denkschr. med. naturw. Ges. Jena, 8: 12, pl. 1, fig. 1.

Athanas setoensis Kubo, 1951, J. Tokyo Univ. Fish., 38 (2): 265, figs 5, 6. Miya & Miyake, 1968, Amakusa Mar. Biol. Lab. 1 (2): 150, fig. 8.

Athanas dimorphus seedang Banner & Banner, 1966b, Siam Soc. Monogr. (3), 28, fig. 4.

Specimens examined: 1 specimen from AM P.9077; 1, BAU 4; 5, BAU 6; 33. BAU 46; 12, BAU 51; 5, BAU 72; 3, US 123608; 1, WM 105–65; 3, WM 229–65.

Diagnosis: Rostrum reaching to or past end of second antennular article, Supracorneal teeth lacking, extracorneal teeth acute, infracorneal teeth slightly projecting and rounded, pterygostomial angle subacute. Visible part of first antennular article 1.6 times longer than second, second and third article subequal. Stylocerite reaching variously from end of second antennular article to middle of third antennular article. Scaphocerite broad, reaching past end of antennular peduncle. Carpocerite reaching past end of second antennular article. Basicerite with strong inferolateral tooth.

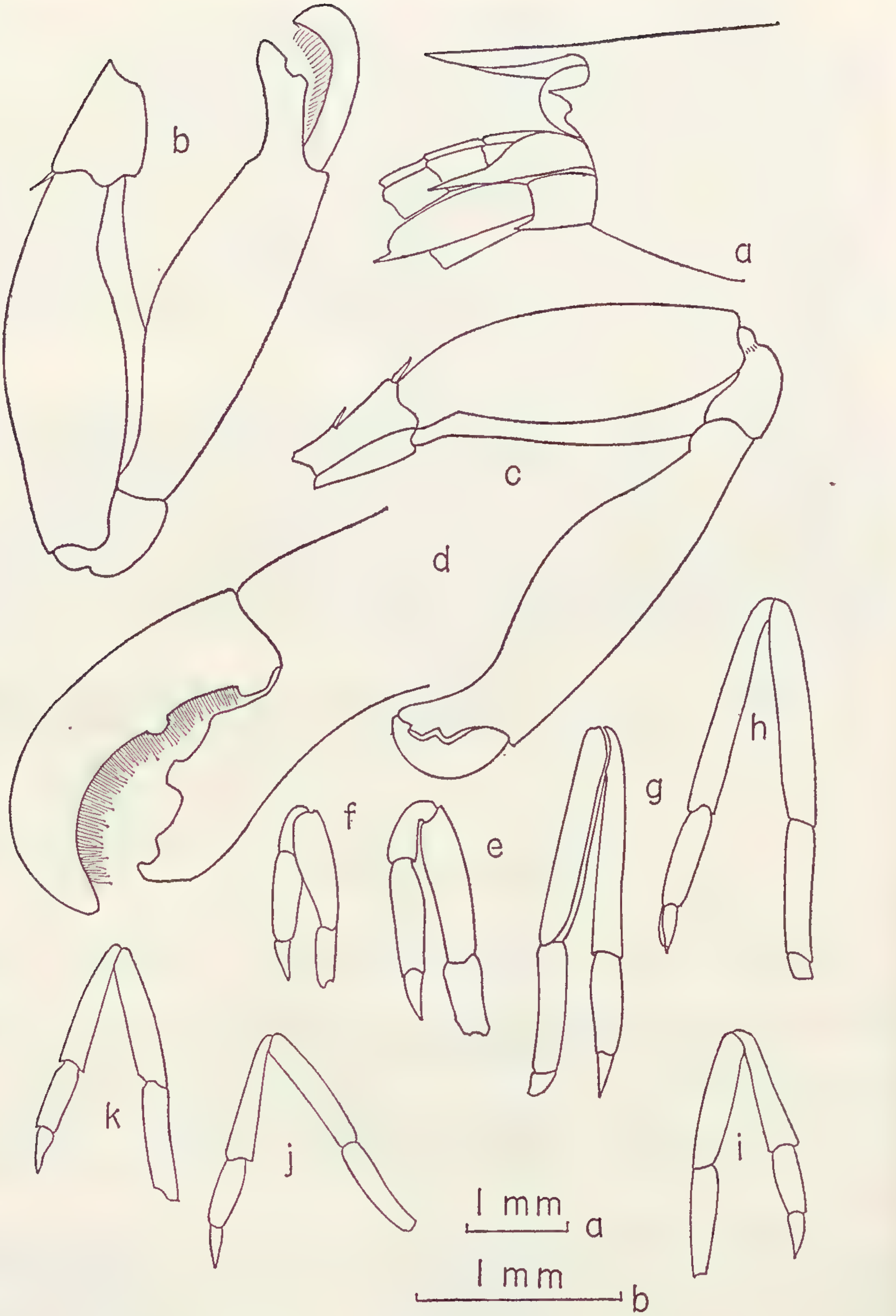


Figure 6.—*Athanas dimorphus* Ortmann. a, anterior region of 14 mm male from BAU 46, lateral view; b, c, large and small chelipeds of 11 mm male from BAU 46, inner face; d, detail of fingers of large chela; e, f, chelipeds from 9 mm male from BAU 46; g, h, chelipeds of 11 mm female from BAU 46; i, j, k, chelipeds of three different females from BAU 46, from 9–10 mm in length. All figures but d, scale a; d, scale b.

Chelipeds sexually dimorphic, but of nearly symmetrical development in both sexes and carried flexed at the meral-carpal articulation. In the female the chelipeds are small and slender. The articles opposed in flexion—the chela and ischium, the merus and carpus—are of similar lengths. The merus varies from 6.5 to 8.8 times as long as broad. The adult male chelipeds are large, robust, inflated. The chela is cylindrical in section but not uniform in diameter, 3 times as long as broad at the greatest diameter at midsection and tapering towards fingers. Dactylus curved, 0.4 as long as palm, fingers at times bearing rounded teeth on both cutting surfaces which pass each other when dactylus is closed, at times without teeth. Cutting surface of dactylus bearing fringe of setae in fully mature males. Carpus one-sixth length of chela. Merus 0.8 length of chela; 3 times as long as broad with inferior face strongly excavated to accommodate chela when flexed. Ischium a little longer than broad, bearing one or two spines on superior margin.

Carpal articles of second legs with ratio of 10 : 1 : 1 : 1 : 4.

Merus of third leg 4.6 times as long as broad. Carpus 0.5 as long as merus. Propodus as long as merus, bearing several spines on inferior margin. Dactylus simple.

Telson as usual, 3.2 times as long as posterior margin is wide.

Discussion: Our specimens agree well with Ortmann's description and figures. The only important variation appeared to be in the small cheliped of the female. We compared the ratio of the chela to the merus in 25 specimens, 14 of them from the same location, and found that the chela varied from half as long as, to equal to, the merus. This variation could not be correlated with size. We also were able to examine 10 females from the Red Sea identified by Coutière at the National Museum of Natural History in Paris and found that in these specimens the chela varied from 0.6–0.9 times as long as the merus.

Ortmann's original figure shows the chela to be 0.6 as long as the merus and Ortmann states only ". . . der merus schlanker, der carpus ebenfalls schlank, mindestens ebenso lang als der merus. Die Scheere ist kurz, kürzer als der carpus".

In 1966b we erected a subspecies *Athanas dimorphus seedang* which we separated from the nominate form by having the chela and merus almost equal in length. The variation we now report destroys the validity of the separation.

In 1951 Kubo established a new species, *A. setoensis*, based on a single 8.6 mm ovigerous female collected in Japan. In 1968 Miya & Miyake further elaborated the description of this species. They had 2 specimens, a male without chelipeds and a female with chelipeds which they found agreed well with the type. The only difference between Kubo's and later specimens was apparently in the infracorneal tooth which Kubo stated was lacking and Miya & Miyake found to be produced but blunt. Ortmann does not mention a tooth and his figure is not clear on this point. We feel that no great importance should be attached to this as this is known to be a variable character in the genus.

Both Kubo and Miya & Miyake separate *A. setoensis* from *A. dimorphus* principally by the relative length of the rostrum to the second antennular article, and the relative lengths of the carpus and merus in the female cheliped. We asked Dr Miya his opinion of the validity of the separation in view of our findings on the variation in these characteristics. He kindly examined 22 specimens from the type locality (near the Seto Marine Biological Laboratory) and found the same type of variation as in our specimens. He supports our conclusion that *A. setoensis* is a synonym of *A. dimorphus*. (Personal communication; perhaps Dr Miya will publish the details of his study in the future.)

Biological notes: Most of our specimens were captured in pools under rocks and coral heads at low tide, but they have also been taken from broken-up coral. The specimens from Thailand were bright red in colour. The specimens from Wistari Reef (US 123608) were described by Moulton as "tan and white striped; blue spot on dorsum of thorax". Our specimens ranged from 8–15 mm in length.

Australian distribution: A. dimorphus has been collected near Perth in Western Australia, from Darwin in the Northern Territory, and in eastern Australia from Yeppoon, Queensland to Port Jackson, N.S.W.

General distribution: This species has been recorded from East Africa, the Red Sea, Thailand, Japan, and New Caledonia. We have some unreported specimens from Hong Kong and the southern Philippines in our collections.

Athanas haswelli Coutière

Athanas hasswelli Coutière, 1908, Bull. Soc. Philomath, Paris IX, 11 (5): 2. [Coutière was in error in the spelling of W. A. Haswell's name in his original description; it is hereby officially changed to *A. haswelli* according to Article 33 (a) (i) of the *International Code of Zoological Nomenclature*, 1961.]

Athanas haswelli Hale, 1927, Crust. of S. Australia, pt. 1; 47 [citation of Coutière only].

Translation of original description: "*Athanas hasswelli n. sp.* This species is closely related to *A. dimorphus* Ortmann and *A. minikoensis* H. C. It differs by the different proportions of the first pair on the female, the only known specimen. The carpus is equal to the meropodite in *A. dimorphus* and larger than the chela (about 1.8). The carpus is here shorter than the meropodite and shorter than the chela (around 0.85). The appendage has the same cylindrical and slender form, which distinguished it from the species *A. minikoensis*, where the chela is more robust and the carpus short. 1 mutilated female from South Adelaide coast, coll. W. H. Baker". [Description without illustrations.]

Discussion: This species has not been reported since Coutière's original description and is not represented in our collections. There is some question as to its validity, for if Coutière was describing an immature female, then its separation from *A. dimorphus* on the basis of the relative length of the carpus of the chelipeds is invalid (see our fig. 6e and f). As can be seen in other species of *Athanas*, the separation Coutière makes between *A. haswelli* and *A. minikoensis* is questionable. Finally, should the species again be found from South Adelaide coast, it should be carefully compared to *A. marshallensis* which is similar in many ways. In case they are found to be identical (which is doubtful, considering the differences in zoogeographic regions), *A. marshallensis* is a junior synonym.

Athanas granti Coutière

Fig. 7

Athanas granti Coutière, 1908, Bull. Soc. Philomath. Paris IX, 11 (5): 192. Hale, 1927, Crust. S. Australia, 47 [citation of Coutière only].

Specimens examined: 2 specimens from AM 61; 1, AM 220; 1, AM 222; 1, AM 261; 1, AM 266; 2, AM 268; 1, AM 269; 2, AM 270; 1, AM 271; 2, AM P.3071; 7, AM P.5028; 2, AM P.6913; 1, AM P.8437; 1, AM P.11271; 5, AM P.11733; 7, WM 153/173.

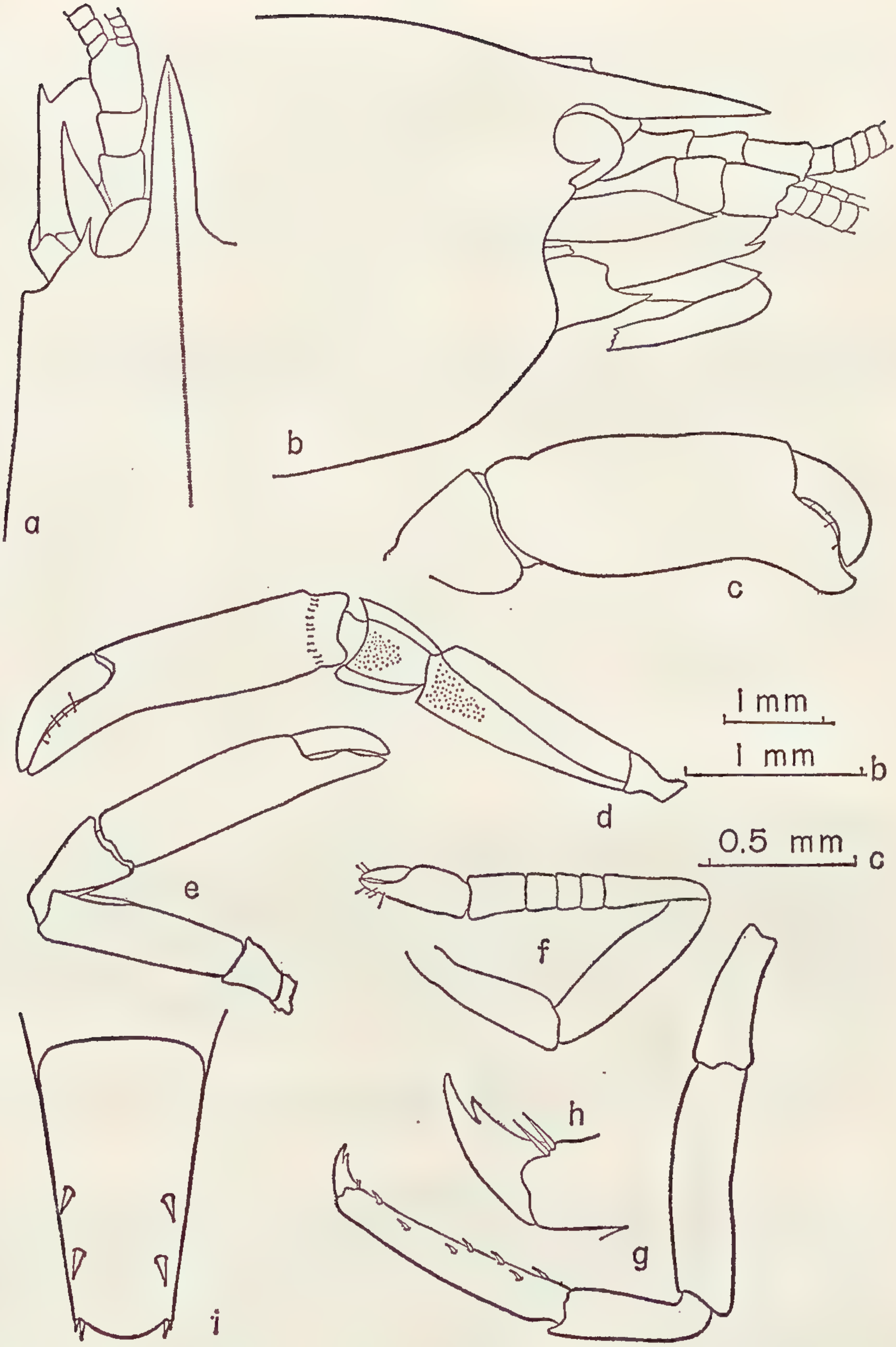


Figure 7.—*Athanas granti* Coutière. a, b, anterior region of 13 mm male from AM P. 5028, dorsal and lateral view; c, large chela, inner face; d, small cheliped, outer face; e, small cheliped of 15 mm male from AM 270; f, second leg; g, third leg; h, dactylus of third leg; i, telson. c, d, e, i scale a; a, b, f, g scale b; h, scale c.

Diagnosis: Rostrum reaching past middle of third antennular article. Supracorneal teeth absent; extracorneal teeth acute, extending forward to past middle of cornea; infracorneal teeth small, rounded. Visible part of first antennular article 1.3 times as long as second. Second antennular article a little wider distally than long; third antennular article 0.7 longer than first. Stylocerite reaching to end of second antennular article. Scaphocerite with outer spine prominent, but not longer than squamous portion which reaches to near end of third antennular article. Carpocerite reaches slightly past middle of third antennular article. Lateral tooth of basicerite acute and triangular, reaching to near end of first antennular article.

Chelipeds not sexually dimorphic in mature specimens, carried extended, but capable of flexion. Chelae almost symmetrical, the larger being 2.3–3.0, the small chela 3.2–3.8 times as long as broad. Both chelae usually with constriction near proximal end. Large chelae often carry a broad, rounded projection on inner side of fixed finger (fig. 7c) fitting into curvature of dactyl when closed; these chelae with stouter palms and carpi than those without teeth. Fingers of small chelae lacking tooth; however, in one specimen the fixed finger carried a slight rounded projection (fig. 7e). Fingers of the small chela usually slender, slightly curved, bearing only a few bristles between fingers. Carpus of large chela cup-shaped, a little more than half as long as merus, expanded distally to accommodate proximal end of palm; merus 2.8 times as long as broad. Ischium half as long as carpus, carrying a superior distal spine. Inferior face of carpus flattened to slightly concave to fit against flattened area on distal end of merus when joint is flexed. Proximal articles of small cheliped similar.

Second leg with ratio of carpal articles 10 : 2 : 2 : 2 : 5.

Ischium of third legs unarmed. Merus inermous, 3.8 times as long as broad with slight superior curvature, 1.6 times longer than ischium. Carpus a little longer than ischium, 3 times as long as broad, bearing strong tooth on its superior margin. Propodus slender, 6.3 times as long as broad, slightly longer than merus, carrying on lower margin 7–12 spines and a pair distally. Dactylus heavy and biunguiculate, 0.17 as long as merus and less than 2 times as long as broad at base. Superior ungui markedly longer and heavier than inferior; inferior unguis often carried at almost right angles to propodus, at other times only slightly curved on inferior surface.

Telson as usual for the group, 3 times as long as broad at posterior margin; anterior margin 1.8 times broader than posterior.

Discussion: Coutière's description, though brief, was explicit. We were also able to confirm the identity of our specimens by comparison with the type at the Museum of Natural History in Paris. *A. granti* most closely resembles *A. areteformis* Coutière, but can be separated by the lack of supracorneal teeth and the biunguiculate dactylus of the third leg. *A. sibogae* De Man and *A. jedanensis* De Man also have biunguiculate dactyli on the thoracic legs, but both show sexual dimorphism in the chelae.

Many of the males of this species bear the small flat process on the fifth abdominal sternum extending posteriorly, similar to that reported for *A. dorsalis* (see fig. 10f).

Biological notes: Almost all of the specimens were collected intertidally. Two were reported from living coral and one was associated with the sea urchin *Centrostephanus rodgersii.* J. C. Yaldwyn supplied the following colour notes from a specimen from Long Reef, Collaroy, N.S.W.: "Very dark purple-black in colour, completely opaque; walking legs 2–5 paler and with alternating bands of purple and very pale purple. Details (through the lens shortly after death): purple colour due to dense mass of interlocking simple red stellate chromatophores and granular blue chromatophores; fewer red chromatophores on carapace than on rest of body; close examination showed a paler stripe down back where there are less red chromatophores and fewer blue granules; eyes black". It was also reported by Miss Pope (AM P.11733) as being "Deep blood red with pale dorsal stripe".

Australian distribution: This species appears to live only in the cooler waters of Australia (below 30° S.) and has not been reported elsewhere. Seven of our specimens were collected in Western Australia at Rottnest; in eastern Australia they were collected only from the coasts of New South Wales. As Coutière's type came from South Australia the species may extend along the entire southern coast of Australia.

Athanas ornithorhynchus sp. nov.

Holotype: 11 mm ovigerous female from Chambers Bay, Van Diemen Gulf, N.T. Taken from pearl shell growth by V. Wells and A. A. Racek, Oct. 1959 (AM P.17999).

Paratypes: One, 10 mm non-ovigerous female from same collection as type (AM P.18000). One, 9 mm ovigerous female from Shark Bay, W.A. (AM P.18001). One, 9 mm female and 1, 10 mm male from Cockburn Sd, W.A., dredged at 10 fms. (CS 2a, 2b).

Description: Rostrum narrowly triangular and acute, reaching well beyond antennular peduncle; with dorsal carina that extends from tip to posterior of corneas, broadening slightly in region of eyes. Supracorneal teeth lacking; extracorneal teeth large, acute, located well above cornea when seen in lateral view, reaching almost to end of first antennular article; slight prominence at usual location of infracorneal tooth. Visible part of first antennular peduncle 2 times longer than second; third 1.5 times longer than second. Second article a little broader than long. Stylocerite heavy, reaching to middle of third article. Scaphocerite with prominent lateral spine reaching past squamous portion; squamous portion reaching almost to end of antennular peduncle. Carpocerite reaching to near end of third antennular article. Spine on basicerite prominent, triangular, reaching almost to end of first antennular article.

Chelipeds asymmetrical. Large cheliped as long as carapace. Ischium 2.3 times as long as broad, bearing 5 spines on superior margin. Merus excavated to accommodate the propodus, 6 times as long as wide in middle, broadening slightly distally; inferomedial margin expanded into a thin lobe that lies over part of the carpus and the carpal-propodal articulation when appendage is flexed. Carpus small, shorter than ischium, cup-shaped, exactly fitting base of palm except for pronounced lobe which extends distally on inferior side (lobe visible in lateral view). Large chela 4.4 times as long as broad in middle. On the inferior side, about two-thirds length of palm, lies a thin lobe which extends over the inferolateral edge of merus when cheliped is flexed. Tips of fingers rounded and slightly crossing. Fixed finger with a low ridge occupying about two-thirds of length, abruptly

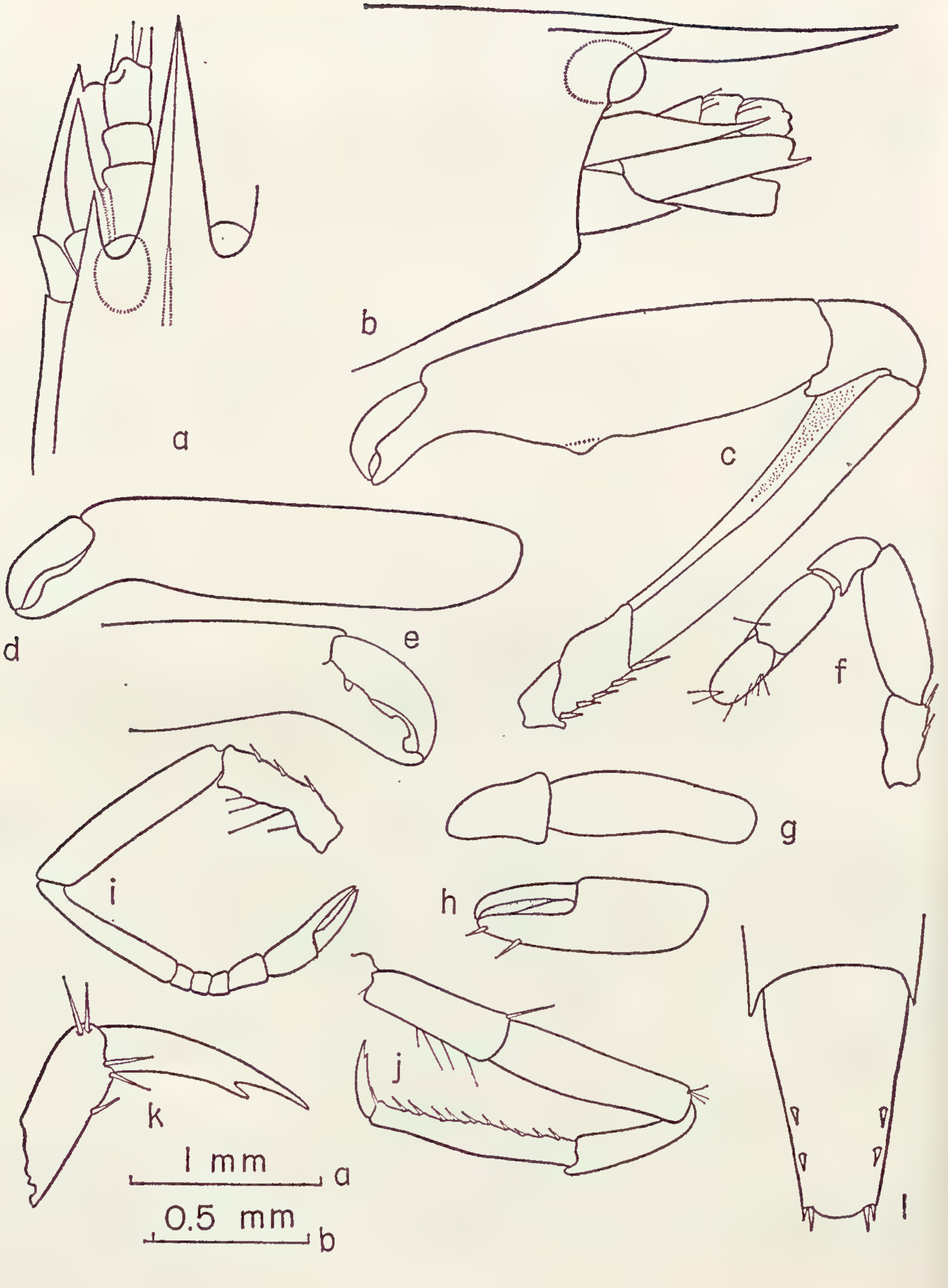


Figure 8.—*Athanas ornithorhynchus* sp. nov. a, b, anterior region of holotype, dorsal and lateral views; c, large cheliped, outer face; d, large chela, inner face; e, detail of fingers of large chela, inner face; f, small cheliped, lateral view; g, small chela, medial view; h, small chela, lateral view; i, second leg; j, third leg; k, dactylus of third leg; l, telson. All figures but k, scale a; k, scale b.

terminating proximally and rising to a low truncate tooth distally that terminates at right angles to cutting surface; distal tip narrow and acute. Dactylus slender, with slight flange proximally and towards middle of article that covers ridge on fixed finger; ridge again expanded into rounded lobe at and beyond truncate tooth of fixed finger; tip curved and acute.

Small cheliped about one-third the length of the large chela. Ischium almost 2 times as long as broad, 2 spines on superior margin. Merus 2.7 times as long as broad, inermous, not excavated. Carpus only 0.3 as long as merus, cup-shaped, slightly broadened at its distal end. Chela 3.2 times as long as wide, fingers 0.7 as long as palm. Fingers flattened and broadened, only twice as long as broad when viewed from lateral aspect. Tips of dactyli broadly rounded and forming a closure like the bill of a duck with opposing surfaces excavated or spoon-shaped. Sparse patches of setae on chela.

Ratio of carpal articles of second leg: 10 : 1 : 1 : 1 : 2. Ischium 0.6 as long as merus bearing 3 spines on superior margin. Inferior margin bearing several strong setae.

Third leg with ischium 0.7 as long as merus and bearing one spine on superodistal margin. Merus 3.8 times as long as broad, inermous. Carpus 0.6 as long as merus, superodistal margin projected. Propodus slender, 7 times as long as broad, slightly longer than merus and bearing numerous spines on inferior margin. Dactylus 0.3 as long as propodus, biunguiculate with inferior unguis only 0.2 as long as superior.

Telson as usual, 3.2 times as long as posterior margin is broad.

Discussion: This species differs from all others known from this genus by the broadened and spatulate nature of the fingers of the small chela and by the flat lobe on the inferior margin of the large chela. Possibly the closest related species is *A. naga* Banner & Banner, which bears 4 small protuberances on the lower margin of the large chela and a similar extracorneal spine; however, in *A. naga* the small chela does not bear spatulate fingers, and the dactylus of the third leg is not biunguiculate.

The name is derived from the similarity of the fingers of the small chela to the bill of the Australian platypus.

The holotype will be deposited in the Australian Museum; the paratypes will be distributed between the Australian Museum and the Western Australian Museum.

Athanas sibogae De Man

Fig. 9

Athanas sibogae De Man, 1910b, Tijdschr. ned. dierk. Vereen. II, 11 (4): 314; 1911' Siboga Exped. 39a^1(2): 151, fig. 6. Miya & Miyake, 1968, Publ. Amakusa Mar. Biol. Lab. 1 (2): 134, fig. 2. [extensive redescription.]

Athanas parvus De Man, 1910b, Tijdschr. ned. dierk. Vereen. II, 11 (4): 315; 1911, Siboga Exped. 39a^1 (2): 148, fig. 4. Kubo, 1940b, Annot. Zool. jap. 19 (2): 99, figs 1, 2. Banner & Banner, 1960, Pacif. Sci. 14 (2): 141, fig. 1.

Specimens examined: 1 specimen from AM 15; 3, AM 68; 1, BAU 27; 4, BAU 40; 2, BAU 43; 8, CS, 1a–1k; 1, WM 40–65; 1, WM 136–65; 1, WM 152–65; 2, WM 187–65; 1, WM 265–65; 1, WM 266–65; 12, WM 288–65; 1, WM 302–65.

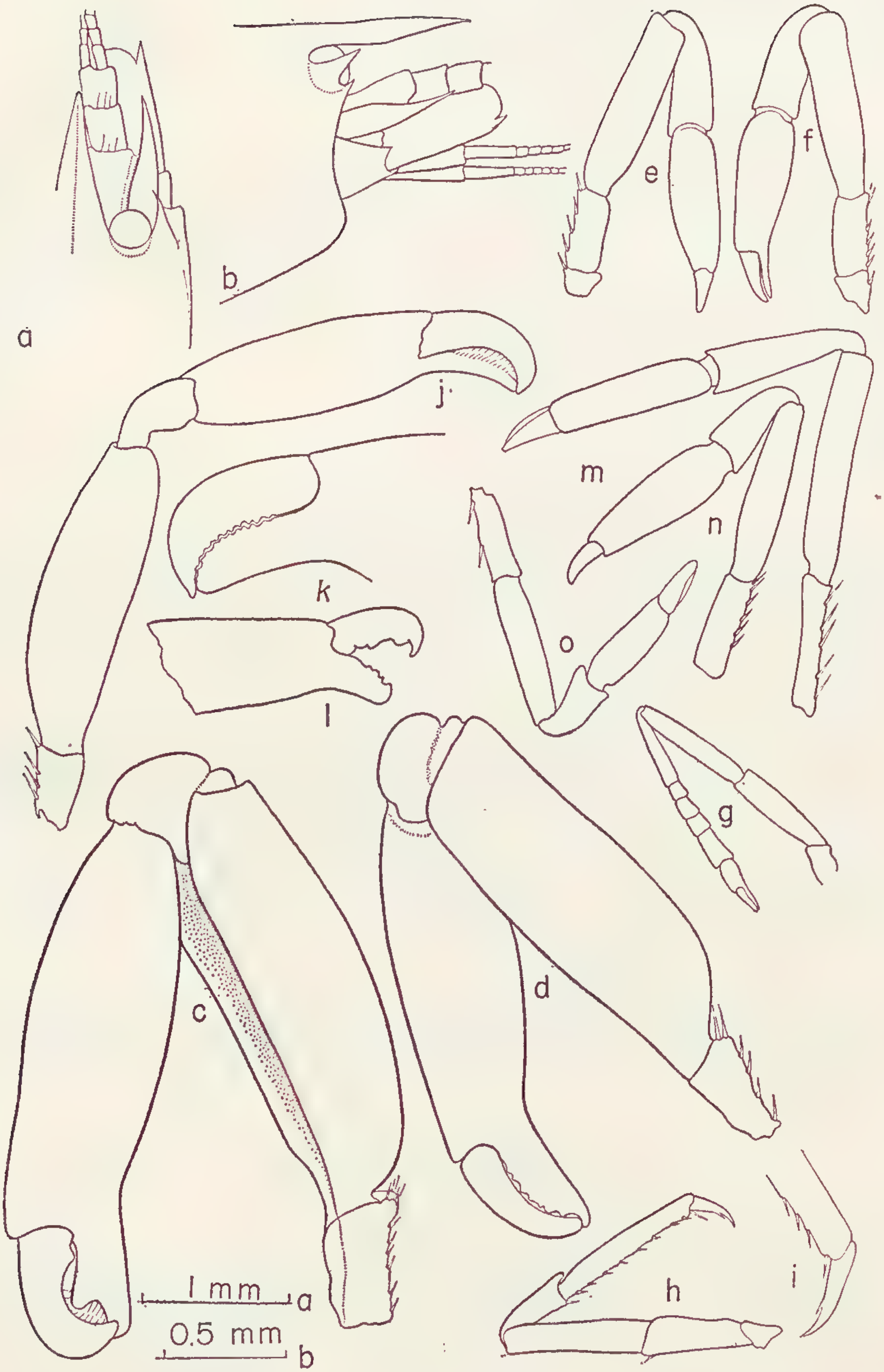


Figure 9.—*Athanas sibogae* De Man. a, b, anterior region of 13 mm male from AM 68; c, large cheliped of fig. a; d, small cheliped of fig. a; e, f, large and small chelipeds of 12 mm female from AM 68; g, second leg; h, third leg; i, dactylus of third leg; j, large cheliped of 14 mm male from 288–65; k, detail of fingers of fig. j; l, detail of fingers of 8 mm male from BAU 27; m, n, o, small chelipeds of three females showing variation. All figures but i, scale a; i, scale b.

Diagnosis: Rostrum reaching to end of second antennular article, with strong rostral carina on anterior half of rostrum which completely disappears at base of orbits. Supracorneal teeth lacking; extracorneal teeth acute, extending far beyond cornea; infracorneal teeth acute, extending slightly beyond cornea. Visible part of first antennular article longer than either second or third article, which are subequal. Stylocerite extending beyond end of second antennular article. Scaphocerite extending beyond end of antennular peduncle, squamous portion broad, lateral tooth acute, as long as squamous portion. Inferolateral spine of basicerite broad at base, acute.

Chelipeds almost symmetrical, sexually dimorphic. Male cheliped stout with chela cylindrical, folding back into an expanded and excavated merus. Chela 3.5 times as long as broad. Ischium 0.2 as long as merus, bearing on its superior margin several strong spines. Dactylus crescent shaped; dentition of opposing margins of fingers variable, bearing either a row of small irregular teeth or one or two large rounded teeth (see fig. 9c, d, j, k, l). Female chelipeds feeble. Ischium bearing about 6 strong spines and equal in length to cylindrical carpus. Merus slightly excavated at distal end, unarmed and equal in length to chela. Fingers slender, almost straight, tapering. Ratios of chelipeds beginning with ischium lie in the range from 10: 23: 1: 23 to 10: 15: 8: 15.

Ratio of carpal articles of second leg 10: 3: 3: 3: 5.

Ischium of third leg with single superior spinule; merus 4.5 times as long as broad; carpus distally with rounded tooth on superior margin, spinules on inferior; propodus with 9 spinules; dactylus biunguiculate, inferior unguis much shorter and more slender than superior.

Discussion: In a group of 13 specimens from Rockingham, W.A., the rostrum was found reaching variously from the end of the second to the end of the third antennular peduncle, the second antennular article of the antennular peduncle was at times longer than wide and at times wider than long, and the numbers of spines on the ischium of the chelipeds varied from 1–5.

In our collection we found only one male with chela that carried the large teeth on the opposing surfaces of the fingers that both De Man, and Miya & Miyake, figure. However, in the genus *Athanas*, characteristically the largest specimens bear the heaviest teeth, and perhaps the specimens in our collections were not fully mature. The other males in the collection carried the type of dentition as shown in our figure 9 d, i, j, k.

De Man established as type and allotype for *S. sibogae* what was apparently a mature male and a younger male which he regarded as a non-ovigerous female, while he separated an ovigerous female with chelipeds typical of this species into another new species, *A. parvus*. We (Banner & Banner, 1960: 214) pointed this out and placed *A. sibogae* in synonymy to *A. parvus*. Miya & Miyake (1968: 134) supported our findings, but pointed out that, on the basis of page priority, *A. sibogae* is the senior name. We accept their views.

Biological notes: This species has been collected in dead coral as well as sponges. It is common intertidally under rocks on sandy beaches. It has been dredged as deep as 70 metres. Our specimens ranged in size up to 13 mm. Miya & Miyake (1968) supply some colour notes for specimens collected in Japan. "The entire animal is generally pale blue in ground-colour, densely scattered with carmine red chromatophores. A broad longitudinal stripe free from pigment or of pale yellow, occurs along the median from the tip of the rostrum to the posterior margin of the sixth abdominal segment. The antennular peduncle except the portion of the stylocerite is free from pigment or pale yellow. The tail fan is uniformly pale blue to deep purplish blue. The eggs are yellowish red."

Australian distribution: This species was collected from Dampier to Rockingham W.A. In the north it was collected from Van Diemen Gulf and Torres Strait. On the eastern coast it was collected from the Whitsunday Group and from the Capricorn Group.

General distribution: Red Sea, Singapore, Indonesia, Japan, Philippines, Tonga, and Samoa Islands.

Athanas dorsalis (Stimpson)

Arete dorsalis Stimpson, 1861, Proc. Acad. Nat. Sci. Philad. 1860: 32. Coutière, 1905a, Fauna Geog. Mald. Laccad. 2 (4): 866, figs 136, 137.

Athanas dorsalis Banner & Banner, 1960, Pacif. Sci. 14 (2): 141, figs 5, 6 [see for synonymy]. Sankarankutty, 1962, J. mar. biol. Assoc. India, 4 (2): 167. Hipeau-Jacquotte, 1965, Bull. Recl. Trav. Stn. mar. Endoume, 37 (53): 247. Suzuki, 1970, Sci. Rep. Yokohama Natn. Univ. Sec. II, #17, p. 12.

Specimens examined: 1 specimen from AM 24; 2, AM 59; 4, AM 90; 2, AM 109; 3, AM 119; 1, AM 225; 11, AM 235; 1, AM 238; 3, AM P.5275; 1, AM P.10312; 2, AM P.13553; 1, RG 536; 1, RG 540; 1, RG 551; 11, RG 620a; 1, RG 620c; 4, RG 620d; 6, RG 620(2)d; 5, RG 621a; 13, RG 622a; 25, RG 622(3)c; 5, RG 623 1/2; 1, WM 22–65; 2, WM 368/9.

Diagnosis: Rostrum broad, varying from 1.0–1.8 times as long as broad; reaching variously from end of first antennular article to middle of third antennular article, with most specimens reaching to end of second antennular article. Lateral margins of rostrum sometimes slightly depressed to form a narrow shelf. Occasionally anterior margins of orbits, lateral to rostrum, with slight prominences. Extracorneal teeth well developed, reaching variously from middle to end of cornea. Supra- and infracorneal teeth absent. Stylocerite curving inward, reaching to near end of antennular peduncle. Scaphocerite reaching to end of antennular peduncle, lateral tooth strong, longer than lamellar portion. Carpocerite stout, as long as scaphocerite.

Large and small chelae similar in size and shape, directed forward. Chelae exhibiting strong growth and sexual differences (see discussion).

Second legs with four carpal articles with the approximate ratio: 10: 2.5: 2.5: 5

Thoracic legs stout. Length-breadth ratio of merus of third leg varies from 3.3–4.0. Tooth on distal end of inferointernal margin is sometimes only an obtuse angle. Dactylus biunguiculate.

Lower border of telson arcuate. Telson varies from 3.2–4.0 times as long as posterior margin is broad.

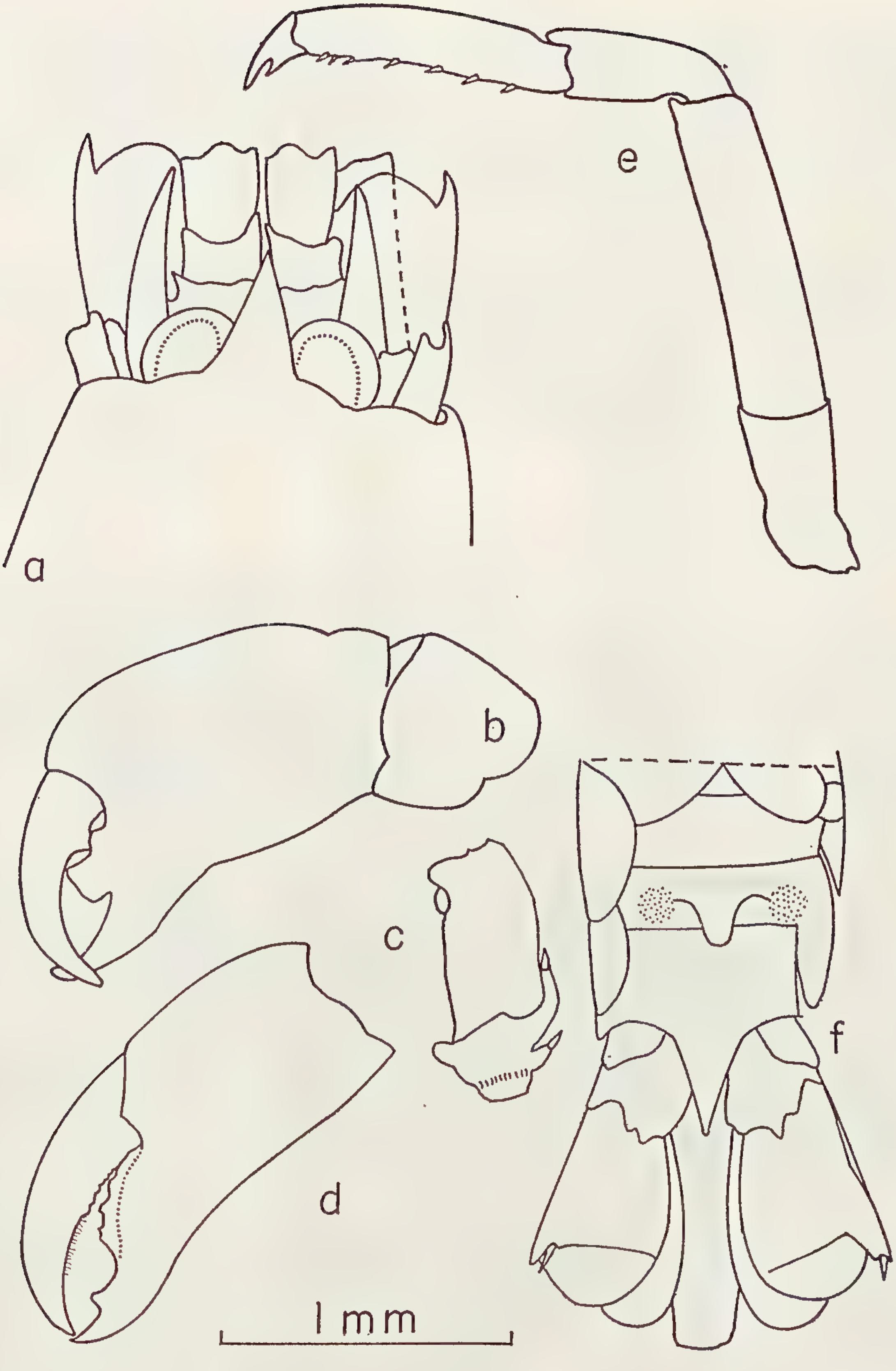


Figure 10.—*Athanas dorsalis* (Stimpson). a, anterior region of 18 mm male from AM P.5275, dorsal view; b, c, large chela and merus, inner face; d, large chela from 10 mm male from AM P.5275; e, third leg; f, ventral view of lower abdomen.

Discussion: In 1960 we discussed the extreme variation of this species. That analysis placed *A. mascarinicus* Richters and *A. maruteensis* (Coutière) into synonymy and left some question as to the validity of the closely related species *A. indicus* (Coutière). To review the separation, we selected 17 complete specimens of *A. dorsalis* in the Australian collection, and 11 complete specimens of *A. indicus* for close comparison. We carefully reviewed the literature on the two species also. We conclude that these two species are separate and can be differentiated by 4 characters, but each of these characteristics is variable:

	A. dorsalis	*A. indicus*
Length of rostrum	Usually to near end of second antennular article.	Usually to near end of third antennular article.
Length/breadth ratio of rostrum.	1.0–1.7	1.8–2.5
Length/breadth ratio of merus of third leg.	3.0–4.0	4.1–5.0
Size of tooth on distal end of inferointernal margin of merus of third leg.	Feeble	Well developed

Four male specimens of *Athanas dorsalis* (all living commensally with sea urchins) carry on the fifth abdominal sternum a long, rounded flap (see fig. 10e) that protrudes ventrally and posteriorly. We also have on hand many specimens of *A. dorsalis* from other areas in the Pacific such as Guadalcanal, New Hebrides, New Britain, Rennell, etc. in which the males carry this flap. Male specimens as small as 5 mm often have this character. One ovigerous female from Samoa carried the flap, but it was much reduced. We also observed a similar flap in *Athanas granti*, but did not observe it in any other species or genera. We offer no suggestions as to the function of the flap, nor of its possibly systematic significance.

As we mentioned in the introduction, Suzuki (1970) shows that *A. dorsalis* and *A. indicus* are protandrous consecutive hermaphrodites. He states: "The external male character can be found in the first pereiopod and second pleopod; in the typical male, the first pereiopods are symmetrical and on the cutting edges of fingers there are prominent teeth, besides minute serrations, and the second pleopod is provided with both an *appendix masculina* and an *appendix interna* on the inner middle portion of its endopodite; in the typical female the first pereiopods are symmetrical, there are nothing but minute serrations and the second pleopod has no *appendix masculina*, the *appendix interna* only". However, as the gonads have both ovarian and testicular tissue at all times, but of varying proportions, these external characteristics are variable in appearance related to degree of male/female function at any particular stage in its life-history.

Biological notes: This species is commonly associated with sea urchins, living between the spines on the oral surface and assuming the colour of its host (Hipeau-Jacquotte, 1965: 47). Specimens from Australia, Norfolk Island, and Lord Howe Island were reported associated with 6 species of sea urchins: *Heliocidaris erythrogama* (Valenciennes), *Heliocidaris tuberculata* (Lamarck), *Centrostephanus tenuispinus* H. L. Clarke, *Centrostephanus rodgersi* (A. Agassiz), *Tripneustes gratilla* (Linnaeus), and *Echinothrix diadema* (Linnaeus). Julie Booth reported upon two different specimens from *Heliocidaris tuberculata* with 2 different colour patterns (notes in collecting vial). One specimen was "orange-red with flesh-coloured dorsal stripes", the other specimen "dark greenish brown. Masses of small green chromatophores and a scattering of simple red chromatophores to give an overall dorsal colour greenish, but laterally and on limbs much paler. No dorsal stripe and no pattern on hand. Eyes black . . .". Suzuki's specimens from Japan were all from *Stomopneustes* sp. and were uniformly black in colour. At Eniwetok in the Marshall Islands it has been found associated with a species of brittle star, *Ophiocoma anaglytica* Ely. In our own collections we found this species only in dead coral heads from reef flat to water 10 ft deep; however, they may have been associated with echinoderms in the coral heads.

Australian distribution: This species has been collected off Western Australia and in eastern Australia from New South Wales to the Herald Group in the Coral Sea. We also have specimens from Lord Howe Island and from Norfolk Island.

General distribution: Stimpson's original specimens came from Hong Kong. It has been reported from the Red Sea, Indian Ocean, Indonesia, Thailand, Japan, China, Kermadec Is., S. Africa, and across the central Pacific from the Marianas Islands to the Tuamotu Archipelago.

Athanas indicus (Coutière)

Fig. 11

Arete dorsalis indicus Coutière, 1903, Soc. Philomath. Paris IX, 5 (2): 84, figs 25–30; 1904, Bull. Mus. Nat. Hist., Paris, 10 (2): 59 [notes on commensalism].

Arete indicus Coutière, 1905a, Fauna Geog. Mald. Laccad. 2 (4): 863, figs 134, 135.

Athanas indicus Banner & Banner, 1960, Pacific. Sci. 14 (2): 149 [see for synonymy]. Hipeau-Jacquotte, 1965, Recl. Trav. Stn. mar. Endoume 37 (53): 247 [notes on commensalism]. Miya & Miyake, 1968, Publ. Amakusa Mar. Biol. Lab., 1 (2): 151, figs 9–12. Suzuki, 1970, Sci. Rep. Yokohama Natn. Univ. Sec. II, #17, 5, figs 4, 5, 6, 7.

Previous Australian records: McNeill 1968. Sci. Rept. Gt. Barrier Reef Exped. 7 (1): 18. Low Isles.

Specimens examined: 2 specimens from AM 74; 6, AM 109; 4, AM 272; 1, AM 392; 1, AM P.8027; 1, BAU 23; 2, RG 536; 1, RG 538; 2, RG 451; 1, RG 542; 1, RG 547a; 1, RG 551; 1, RG 624; 1, WM 135–65; 1, WM 153/173.

Diagnosis: Rostrum triangular, lateral margins slightly depressed forming slight platforms, tip reaching past first quarter of third antennular article. Extracorneal teeth well developed, reaching usually to end of cornea; supra- and infracorneal teeth absent. Antennular peduncle stout, second article broader than long. Stylocerite curved inward, reaching almost to end of antennular peduncle. Scaphocerite reaching to end of antennular peduncle. Carpocerite stout, a little shorter than antennular peduncle.

Chelipeds slightly asymmetrical, carried forward. Carpus cup-shaped, inferior face excavate. Chela exhibiting the same variation in dentition as discussed for *A. dorsalis.*

Four articles of carpus of second leg with ratio: 10: 2.5: 2.5: 5.

Thoracic legs stout. Merus of third leg 4 to 5 times as long as broad, and bearing strong acute tooth on distal end of inferointernal margin of merus. Dactylus biunguiculate.

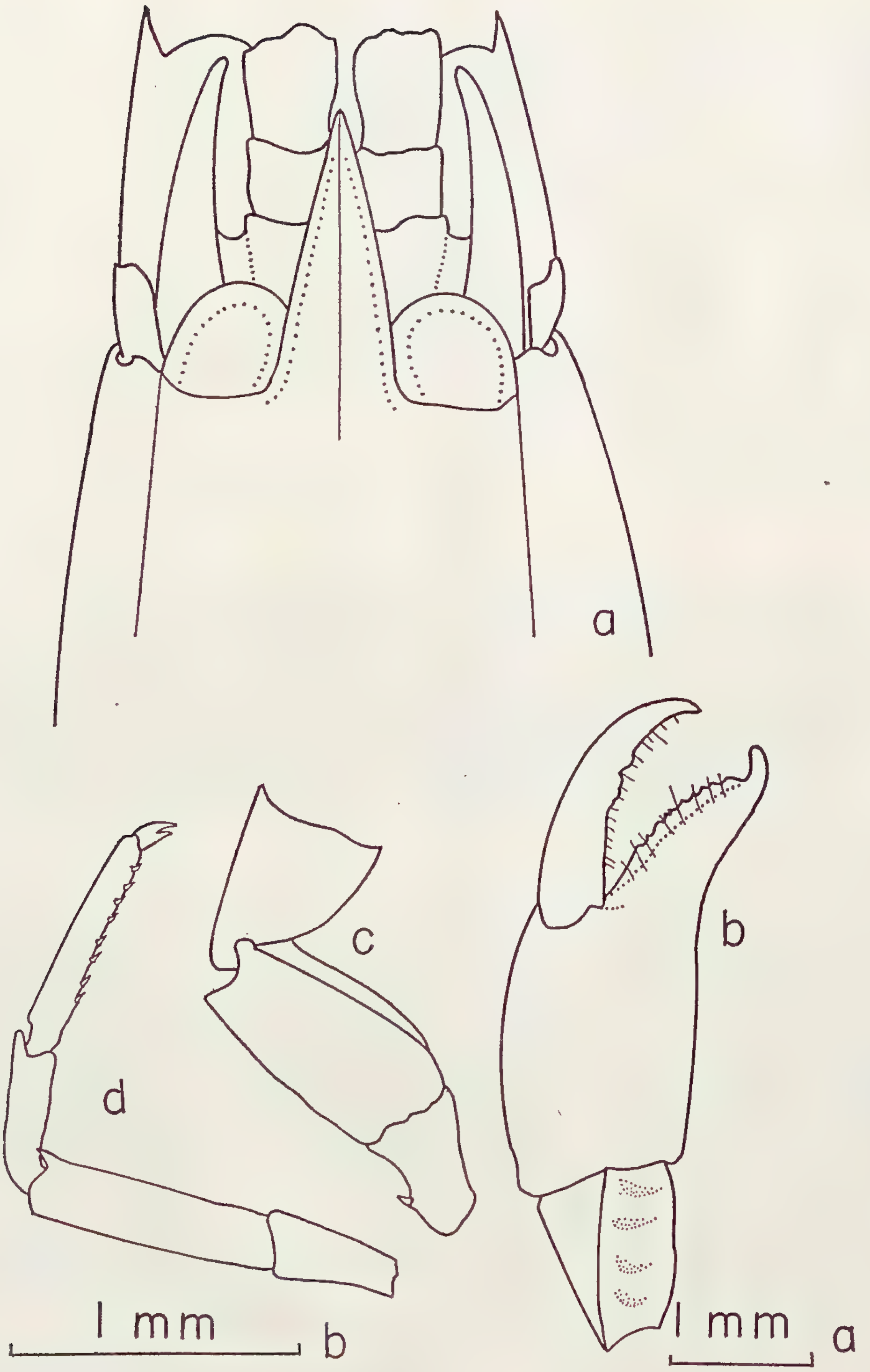


Figure 11.—*Athanas indicus* (Coutière).—a, anterior region of 12 mm male from BAU 23, dorsal view; b, c, large chela and merus, inner face; d, third leg. b, c, d, scale a; a, scale b.

Posterior border of telson arcuate. Telson 3.4 times as long as posterior margin is broad.

Discussion: The similarities between this species and its close relative, *A. dorsalis*, were discussed under that species (see Banner & Banner, 1960: 149). This species, like *A. dorsalis*, has been reported by Suzuki to be a protandrous consecutive hermaphrodite (1970: 32).

Suzuki (1970: 5) feels that *A. kominatoensis* is different from *A. indicus* in 2 characteristics: the pterygostomial angle is rounded in *A. kominatoensis* while it is more angular in *A. indicus*, and the distolateral margin of the palm is rounded in *A. kominatoensis* while it is angular in *A. indicus*. We have found these two characteristics to be variable and we reserve judgement on the validity of his separation.

Suzuki also gives a colour key to the species of *Athanas* from Japan. He reports for Japan but a single echinoderm host for each individual species. As we and some of the individuals who furnished specimens for this study have remarked, the colour of the shrimp matches that of the host echinoderm (see also Potts, 1915a: 61), and as these species apparently are associated with various hosts in the richer tropical Indo-Pacific fauna, we doubt if these colour distinctions will be valid for the tropics.

Biological notes: This species is apparently always associated with various echinoderms, and in our collections it was reported from urchins of the genera *Echinometra*, *Diadema*, *Centrostephanus*, and *Echinothrix*. Perhaps it is most common in association with *Echinometra* (Banner & Banner, 1960: 149) both amongst the spines and in the cavity ground into the substrate by the urchin. On Gillett Cay and on Swain Reefs it was found associated both with the urchin *Diadema* and an unidentified crinoid.

For some specimens associated with *Diadema* sp. (AM 392) the following colour notes were supplied by J. C. Yaldwyn. "White line dorsally along carapace; laterally a red-brown band above and below with a white band between, all longitudinal; irregular white along ventral edges of abdominal segments; hands, legs, pleopods all bluish-green, but colour not dense." When seen through the lens he observed "simple, stellate, red chromatophores, granular blue chromatophores (usually associated with simple red ones) and simple opaque white chromatophores. Eyes black and visible under carapace, white dorsal and abdominal ventrolateral bands with opaque white chromatophores. Lateral white stripe along body clear with no chromatophores; lateral red-brown band of simple red chromatophores and some granular blue; hand with more granular blue chromatophores than red; legs, pleopods and tail fan with both simple red and granular blue; fresh eggs yellow-brown".

Our specimens ranged in size up to 15 mm.

Australian distribution: In Western Australia this species was collected at Rottnest and Cape Naturaliste. In eastern Australia it has been collected from south Queensland to the Coral Sea. We also have 3 specimens from Norfolk Island.

General distribution: Red Sea, Persian Gulf, Indian Ocean, Madagascar, Indonesia, China, Japan; across the Central Pacific from the Marshall Islands to the Tuamotu Archipelago.

Genus **ARETOPSIS**

Aretopsis De Man, 1910b, Tijdschr. ned. dierk. Vereen. II, 11: 310.

Type species: Aretopsis amabilis.

Definition: (From De Man, loc. cit.) ". . . closely related to *Arete* Stimpson. Looked at from above, the short rostrum appears acute, triangular, carinate, without any trace of supracorneal teeth; in a lateral view it appears strongly compressed, with rounded tip, as in the genus *Athanopsis*. Extracorneal teeth wanting, infracorneal teeth (outer angles of the orbits) acute, dentiform. Eyes as in *Arete*. Pterygostomian angle rounded. Pleura of sixth abdominal somite articulate, movable.

"Antennal region as in *Arete*, but stylocerite shorter, only one cheliped is known, it resembles the smaller of *Arete*. Meropodite short, not vaginiform; carpus short, cyathiform. [Small] chela compressed, turned outward, with both margins of the palm entire, but with a small groove on the upper (inner) surface just behind the articulation of the dactylus. Fingers compressed, cutting-edges sharp, that of the dactylus finely denticulate.

"Legs of second pair with the carpus as in *Synalpheus*, 5-articulate. Following legs stout, meropodite unarmed, dactylus biunguiculate."

To De Man's analysis can now be added: large chela laterally compressed, superior and inferior margins sharply carinate, fingers with heavy molar processes. Anal tubercles present; posterior border of telson truncate to rounded.

Aretopsis amabilis De Man

Fig. 12

Aretopsis amabilis De Man, 1910b, Tijdschr. ned. dierk. Vereen. 11 (4): 311; 1911, Siboga Exped. 39a^1 (2): 171, fig. 14. Miyake & Miya, 1967, J. Fac. Agric. Kyushu Univ., 14 (2): 267, figs 1, 2. Banner & Banner, 1968, Micronesica 4 (2): 272. Bruce, 1969, J. Mar. biol. Ass. India 11 (1 & 2): 175, figs 1–4.

Aretopsis aegyptica Ramadan, 1936, Bull. Fac. Sci. Egyptian Univ., No. 6: 16, pl. 1, figs 9, 10; pl. 2, figs 9–17. Holthuis, 1958, Bull. Sea Fish. Res. Stn., Israel, No. 17: 14, fig. 5.

Specimens examined: 1 specimen from AM 120; 1, AM P.8028.

Diagnosis: Rostrum triangular, broader at base than long, tip rounded and reaching just past first antennular article; inferior side of rostrum compressed laterally. Infracorneal tooth strong, acute, reaching past midcornea in lateral view; pterygostomial angle rounded, not protruding. Corneas almost fully exposed in lateral view, but half concealed in dorsal view. Antennular articles subequal; second article as long as wide, third article the longest. Acute tip of stylocerite reaching to middle of second antennular article. Squamous portion of scaphocerite broad, reaching to end of antennular peduncle. Terminal spine on outer margin heavy, twice as long as broad at base and reaching well beyond squamous portion. Carpocerite heavy, reaching more than the length of the third article beyond that article. Basicerite bearing strong tooth laterally.

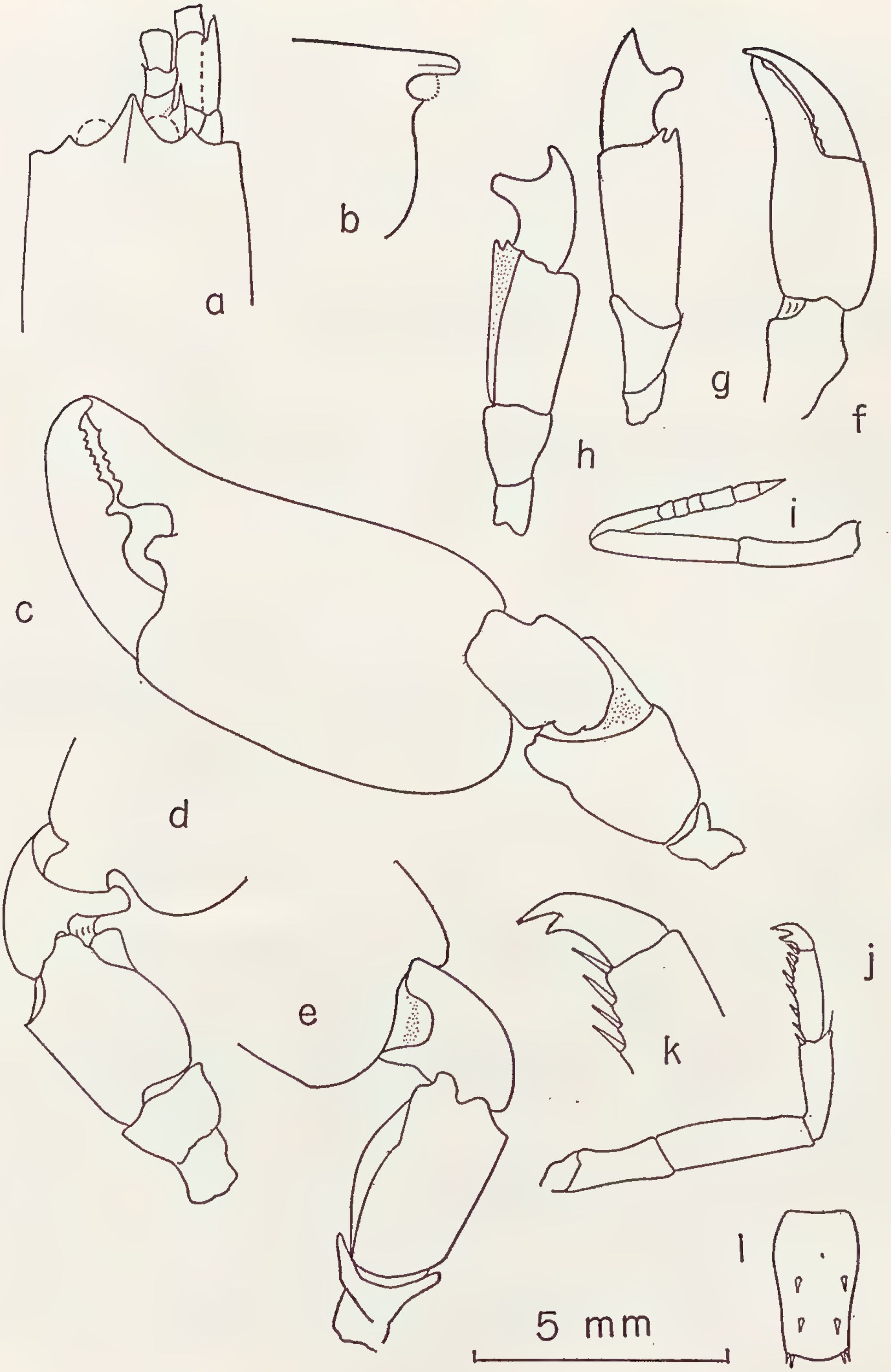


Figure 12.—*Aretopsis amabilis* De Man. a, b, anterior region of 21 mm male from AM 120, dorsal and lateral views; c, large cheliped, outer face; d, e, merus of large cheliped, inner and outer face; f, small chela; g, h, merus of small cheliped, inner and outer face; i, second leg; j, third leg; k, dactylus of third leg; l, telson.

Chelipeds asymmetrical, carried extended in an inverted position with propodal finger uppermost. Large chela laterally compressed, 2 times as long as broad with fingers occupying distal third. Superior and inferior margins sharply carinate. Dactylus strong, curved towards fixed finger. Dactylus with 2 heavy molar processes while fixed finger carries a similar process which fits into the curve of the dactylus proximally. Distally both fingers carry a series of rounded serrations that mesh when fingers are closed; serrate ridge on fixed finger demarcated proximally by smaller molar process; serrate ridge on dactyli continues almost to hooked acute tip; tips of fingers acute and crossing. Carpus cup-shaped, 1.5 times as long as broad, distally carrying one broad flat projection reaching over basal portion of palm and on opposite distal edge a more narrow projection (see fig. 12 c, d, e). Merus almost 2.0 times as long as broad, bearing distally on outer face two rounded projections and on inferointernal face a slight rounded projection.

Small chela 2.7 times as long as broad with dactylus also in inverted position. Fingers equal to palm. The cutting edge of dactylus bearing rounded serrations its full length while fixed finger is smooth and sparsely setose. Fingers crossing at tips. Carpus of small chela similar to that of large chela. Merus 3.0 times as long as broad, bearing distally on inferointernal margin two acute teeth; distally on inferoexternal margin only a rounded projection.

Second leg bearing numerous fine setae on carpal articles particularly on end of terminal article. Fingers hirsute. Ratio of carpal articles 10: 2: 2: 2: 5.

Third leg with ischium unarmed, 3.5 times as long as broad and 0.7 as long as merus. Merus 4 times as long as broad, unarmed. Carpus 0.5 as long as merus; superodistal margin not projected; distoinferior margin bearing spine; superior margin with a few setae. Propodus only slightly longer than carpus, inferior margin bearing 6–8 movable spines on proximal half and 5 pairs of spines on distal half. Dactylus biunguiculate with ungui subequal in basal breadth, but with superior unguis much longer.

Telson as normal for family, 3.2 times as long as broad posteriorly, spines on dorsal surface small, posterior margin slightly convex.

Discussion: Our specimens agree well with De Man's (1911: 171) except for the ratio of the antennular articles, small differences in the appearance of the chela, and the appearance of the distal margin of the telson. In his 11 mm specimen from Indonesia the second antennular article is shorter than the visible part of the first while in our specimens the antennular articles are very nearly equal. The chela figured by De Man was without doubt the small chela which normally lacks the heavy molar processes that occur in the large chela of the adult form. Finally in De Man's specimen the posterior margin of the telson is truncate while in ours it is rounded. The significance of this character is difficult to interpret. De Man stated of his 11 mm female "Anal tubercles probably wanting". In all of our specimens the anal tubercles were present, but in the small specimens they are difficult to see.

Miyake & Miya (1967: 267) described and figured an 18 mm ovigerous female from Okinawa. The only difference between their specimen and our specimens is the length of the scaphocerite, which extends well beyond the antennular peduncle in their specimens.

The matter of secondary sexual characteristics in this species may be confused, as it is in the genus *Athanas* which has species that are protandrously hermaphroditic (see Suzuki, 1970: 1). Miyake & Miya (loc. cit.) reported that their ovigerous female carried an *appendix masculina* on the second pleopod. We have cohabiting "pairs" collected from the interior of shells of hermit crabs in the Marshall Islands. In all cases one specimen was notably larger than the other and none were ovigerous. We presumed that the individuals in the pair would be of opposite sexes, as they are in the higher genera. However, in one pair both individuals carried an *appendix masculina* although their body lengths were 16 mm and 12 mm; in the other two pairs one had the male the larger, the other had the female the larger. In a specimen from Swain Reefs of 25 mm the *appendix masculina* was larger than the *appendix interna*, while in Miyake & Miya's ovigerous female and in a 15 mm specimen from the Marshalls the *appendix masculina* is markedly shorter and thinner than the *appendix interna*.

In two of our specimens less than 12 mm in length the fingers of the large chela lacked the heavy molar processes and bore serrated edges on the cutting surfaces similar to the small chela for the larger specimens (fig. 12f). We feel that the type of dentition on the fingers of the large chela may be an indication of maturity, but we do not have enough specimens to present a growth series.

Ramadan (1936) described another closely related species of this genus, *A. aegyptica*. He separated the two species by only two criteria; first, in *A. aegyptica* the eyes were completely covered by the carapace; second, *A. aegyptica* had anal tubercles. In the ovigerous female of *A. amabilis* described by Miyake & Miya the eyes appear to be half covered by the carapace; in De Man's figure 14 (1915) the carapace covers about one-fourth of the eyes. In the specimen of *A. aegyptica* figured by Holthuis (1958: fig. 5) the carapace covers more than half the eyes. Holthuis said that he believed in the case of Ramadan's specimens the eyes were merely retracted and we support this view. We have seen rotation of eyes in respect to carapace margin in other genera as well. We do not believe that such a variation in the coverage of the eyes by the carapace can constitute a valid character for specific separation.

On the basis of examination of our specimens and careful comparison of those reported in the literature, we have concluded that we are dealing with a single species that is variable in degree of eye coverage, chela formation, antennular proportions, and other slight variations. We therefore place *A. aegyptica* into synonymy and combine the reported ranges.

Only one other species of this genus has been described, that of *A. manazuruensis* by Suzuki (1971: 19) from Sagami Bay, Japan. It is separated from *A. amabilis* principally by having symmetrical first chelipeds.

Biological notes: This species has been reported as dwelling on coral reef flats by De Man, by Miyake & Miya, and in the Australian collection notes. However, all of our Marshall Island specimens were symbionts, one pair in the pelecypod *Pterocera* and three pairs in the shells of hermit crabs. Bruce (1969) reported three pairs from the Seychelles Islands, each pair living in the shell carried by a large hermit crab [*Dardanus sanguinolentus* (Quoy & Gaimard), *Dardanus megistos* (Herbst)]. He suggested that they may be "faecal feeders and help to keep the cavity of the gastropod shell clean". Bruce also reports that the basic colour of these specimens was a deep red with a broad, white, dorsal strip lying mid-dorsally. The band is separated from the red by a narrow zone of orange. *A. manazuruensis* was also living commensally with a hermit crab *Aniculus aniculus* (Fabricius).

Australian distribution: The only two Australian specimens were found on the southern portion of the Great Barrier Reef.

General distribution: Gulf of Aqaba; Eylath, Israel; Seychelles Is.; Indian Ocean; E. Borneo; Okinawa and Marshall Islands.

Genus **SALMONEUS**

Salmoneus Holthuis, 1955, Zool. Verh., Leiden (26): 88.

Jousseaumea Coutière, 1896, Bull. Paris Mus. Hist. Nat., 2 (8): 381.

Type species: Jousseaumea serratidigitus Coutière.

Definition: Carapace anteriorly projecting far beyond eyes as a broad triangular rostrum, and usually with shorter orbital teeth. Eyes completely concealed dorsally and usually laterally.

Chelipeds markedly asymmetrical. Large chela massive, carried under the body, flexed at meral-carpal articulation. Carpus of large cheliped cyathiform, anterior border trilobate, merus of palm of chela excavate to accommodate flexion. Small chela diminutive, with chela shorter than carpus; carpus elongate and slender.

Second legs with carpus of five articles. Posterior thoracic legs as usual for *Alpheus*, dactyli simple.

Pleura of sixth abdominal segment not articulate.* Telson attentuated, no anal tubercles, posterior border usually emarginate.

Branchial formula: 5 pleurobranchs; 1 arthrobranch; 8 epipodites.

Salmoneus tricristatus Banner

Fig. 13

Salmoneus tricristata Banner, 1959, Pacif. Sci. 13 (2): 131, fig. 1. Banner & Banner, 1968, Micronesica 4 (2): 270.

Specimen examined: 1 specimen from BAU 46.

Diagnosis: Triangular rostrum and orbital teeth each bearing slight carinae which extend posteriorly almost the full length of the carapace. Rostral carina bearing slight rounded projection about mid-carapace. Antennular articles short and thick. Stylocerite large, bearing on inner proximal section a slight ridge that demarcates a medial triangular area. Squame broad with lateral tooth small. Carpocerite reaching only to end of second antennular article.

Large chela angular, somewhat square in section, 2.7 times as long as broad, finger occupying distal 0.4. Upper margin with ridges, lower margin with two ridges extending from base of finger to full length of palm, area lateral to the ridge on inner side slightly flattened. Shallow depression on proximal portion of inner face of palm to accommodate merus when cheliped is flexed. Opposing surfaces of fingers gaping, carrying 10–12 distinct teeth that intermesh when fingers are closed. Distal section of fingers free of teeth; tips acute, curving and crossing. Carpus corolla-shaped with 5 lobes on distal margin in part enclosing, and in part fitting into, the irregularities of the proximal end of palm (see fig. 13e). Inner face flattened but not excavated. Small chela extremely small and thin, not longer than second leg.

Ratio of carpal articles of second leg: 10: 2: 2: 2: 3.

---

* Dr Chace has called our attention to an error we made in the discussion of *Salmoneus tafaongae* Banner & Banner (1966: 156) wherein we stated the species, has, rather than lacks, the articulated pleura of the sixth abdominal somite. We have re-examined the original notes (the holotype was lost) and discover the error crept in during the rewriting of the paper for publication.

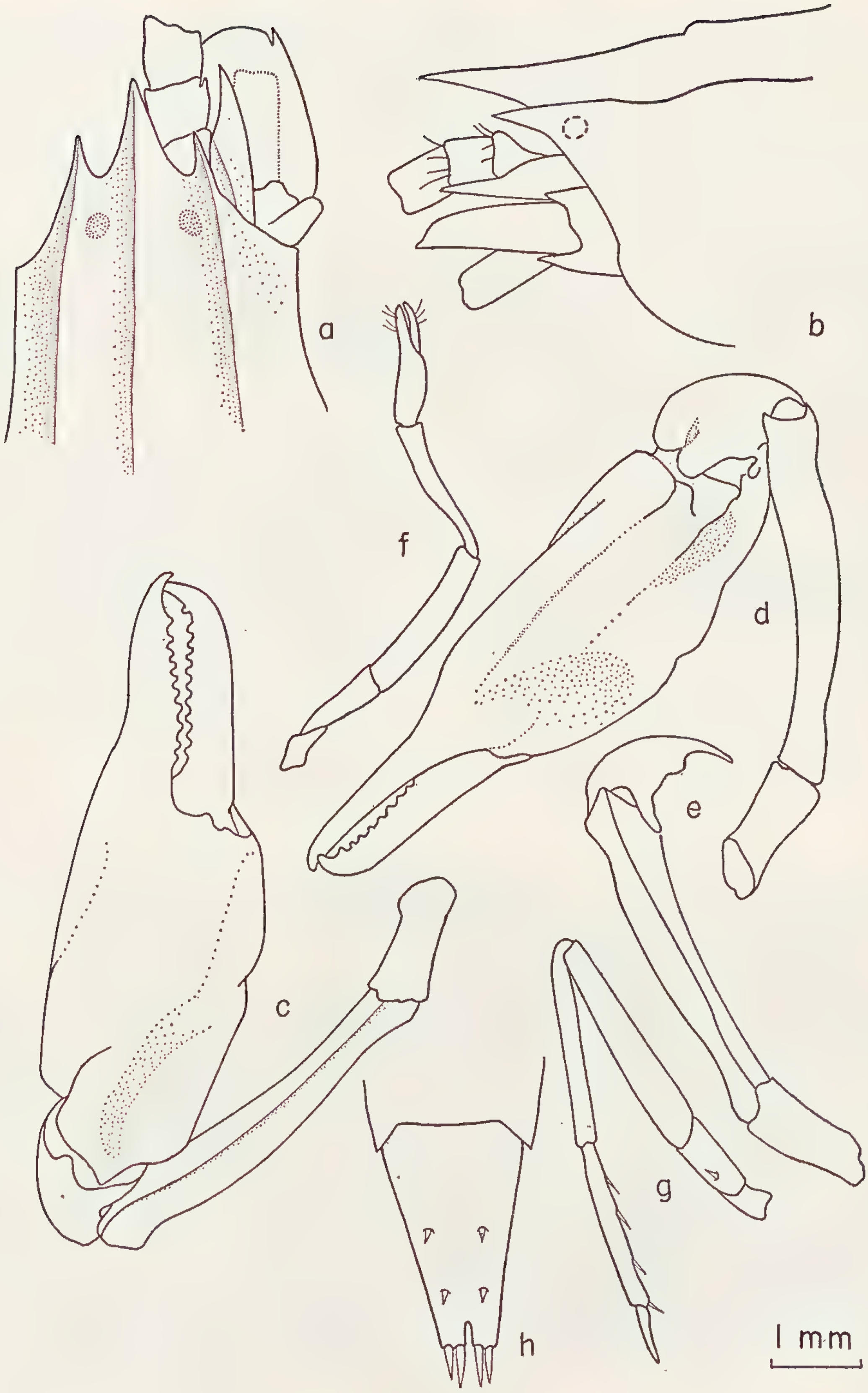


Figure 13.—*Salmoneus tricristatus* Banner. a, b, anterior region, dorsal and lateral view of 17 mm female from BAU 46; c, large cheliped, dorsal view; d, large cheliped, ventral view; e, merus of large chela, inner view; f, small cheliped; g, third leg; h, telson.

Merus of third leg 5 times as long as broad, inermous; carpus about two-thirds as long and less than half as broad as merus; propodus slightly shorter and thinner than carpus, armed with 4 feeble spines on superior margin and two similar spines on inferior, distally bearing a pair of strong spines; dactylus half as long as propodus, slender, tapering, and with slight curve.

Telson 4 times as long as broad at posterior end; posterior margin with deep notch with parallel sides and anteriorly rounded.

Discussion: We do not know how much of the sculpturing that we have depicted on the large chela is natural and how much is from shrinking in preservation. Our 4 specimens with intact chelae from the Marshall Islands were lost (Banner & Banner, 1968), but from our notes it is evident they carried the longitudinal ridges and flattened areas. Thus the longitudinal ridges on the lower side of the chela as well as the groove for the merus are characteristic, but the depressed area near the base of the fingers on the lower face, the depressed areas on the upper face and the notch on the margin towards the merus may be artifacts.

This species is most closely related to *S. sibogae* (De Man) the only differences being: (1) in the lateral crests of the carapace which are lacking in *S. sibogae*; (2) in the more slender proportions of the third leg; and (3) in the notch in the posterior end of the telson which in this species has parallel sides while in *S. sibogae* it is more triangular in shape.

Biological notes: This specimen, like all previously reported specimens of this species, was found under beach rock at low tide; no symbiotic association has been observed.

Australian distribution: Our only specimen was found at Heron I. in the Capricorn Group.

General distribution: Caroline and Marshall Islands.

Genus **ALPHEOPSIS**

Alpheopsis Coutière, 1896, Bull. Mus. Hist. Nat., Paris, 2 (8): 382.

Type species: Betaeus trispinosus Stimpson.

Definition: Frontal border of carapace produced into rostrum and projecting flange that screens eyes from above; orbital teeth present or absent. Cornea of eyes always visible from front and in some species from sides.

Antennular peduncle short and stout; stylocerite variable. Scaphocerite usually broad, lateral spine of moderate development. Carpocerite long.

Chelipeds showing asymmetry. Large chela carried extended, without sheaths or grooves. Carpus cup-shaped, merus roughly triangular. Palm either entire and subcylindrical or with lines and depressions. Fingers compressed, either without teeth or with simple arrangement of exactly fitting teeth.

Second thoracic legs with carpus of three (*A. idiocarpus* Coutière), four (*A. tetrarthri* Banner) or five secondary articles.

Following legs robust, without teeth on merus; propodus weakly spinose; dactylus biunguiculate or simple. Propodus of fifth legs with or without "brush" or bristles.

Sixth abdominal segment lacking articulated pleura only in *A. biunguiculatus* Banner. Posterior border of telson convex.

Branchial formula: 5 pleurobranchs, 0–1 arthrobranch, 6, 7 or 8 epipodites.

Key to the Species of the Genus Alpheopsis in Australian Waters

1.	Anterior region of carapace with rostrum and orbital teeth	2
—	Anterior region of carapace without orbital teeth	3
2. (1)	Chela with longitudinal as well as transverse groove....	*A. trispinosus* (p. 337)
—	Chela without sculpturing	*A. undicola* (p. 340)
3. (1)	Chela subcylindrical	*A. equalis* (p. 342)
—	Inner face of chela flattened, outer face rounded	*A. yaldwyni* (p. 344)

Alpheopsis trispinosus (Stimpson)*

Fig. 14

Betaeus trispinosus Stimpson, 1861, Proc. Acad. Nat. Sci. Philad. 1860: 32 [Port Jackson]. Haswell, 1882, Cat. Australian Crust.: 192 [translation of Stimpson's description].

Alpheopsis trispinosus Coutière, 1896, Bull. Mus. Hist. Nat., Paris 3: 382. Hale, 1941 Rep. BANZ Anarct. Res. Exped. 4 (9): 266, fig. 4 [E. Tasmania]. Holthuis 1951, Atlantide Rep. (2): 94. Coutière, 1899, Les Alpheidae: 73, 190, 259 315, figs 26, 96, 120, 168, 228, 231, 315, 396.

Nec Alpheopsis sp. De Man, 1922, Siboga Exped. $39a^4$ (5): 24, pl. 3, fig. 12.

Nec Alpheopsis sp. Banner & Banner, 1966a, Pacif. Sci. 20 (2): 156.

Additional Australian records:

Whitelegge, 1889, J. Roy. Soc. N.S.W., 23 (2): 224. [Port Jackson.]

Neotype: 19 mm male from Green Cape, N.S.W. Trawled from 30 fms. Coll. M. Boardman, 20/7/25 (AM P.8230).

Additional specimens: 1, 14 mm female from Two Fold Bay, N.S.W. (AM 122); 1, 14 mm male from 40 mi. W. of Kingstone, S.A. (AM E.6274); 1, 11 mm male, 1, 15 mm female from Norah Head, N.S.W., 26–28 fms. (AM P.5349); 1, 16 mm male from Ulladulla, N.S.W., 74 fms. (AM P.9221); 1, 17 mm female, 1, 11 mm female, 1, 15 mm female and 1, 12 mm male from off Green Cape, N.S.W., 39–40 fms. (AM P.7379).

Diagnosis: Rostrum reaching half the length of the first antennular article and a little longer than wide, with concave margins. Orbital teeth acute, broader and shorter than rostrum. Eyes largely covered in dorsal and half covered in lateral view. Pterygostomial angle not produced, rounded. Articles of antennular peduncle subequal, second antennular article 1.5 times as long as wide. Stylocerite reaching to middle of second antennular article. Squamous portion of scaphocerite relatively narrow and reaching just past middle of third antennular article, lateral spine well developed, reaching to end of antennular peduncle. Carpocerite almost as long as squame. Lateral spine of basicerite heavy and acute.

---

* In personal correspondence Dr J. C. Yaldwyn has indicated that he believes his species *A. garrick* (1971: 87) may prove to be a synonym of this species as redefined. We will await his further analysis.

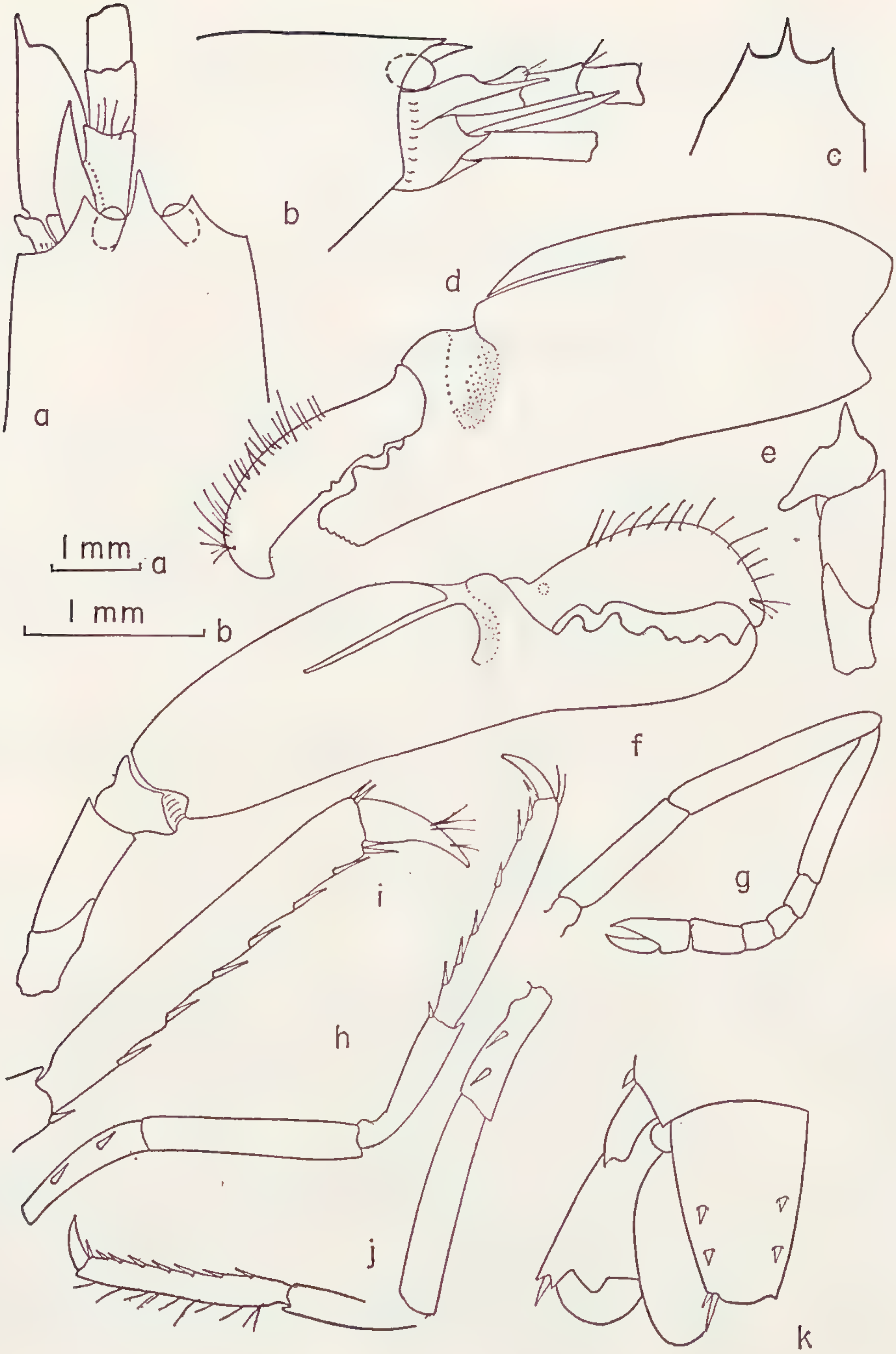


Figure 14.—*Alpheopsis trispinosus* (Stimpson), neotype. a, b, anterior region of neotype, dorsal and lateral views; c, anterior region of 16 mm female from AMP 7221; d, large chela inner face (tip of fixed finger broken); e, merus and carpus of large chela; f, small cheliped, inner face; g, second leg; h, third leg; i, propodus and dactylus of third leg enlarged; j, fourth leg; k, telson and uropods. All figures scale a, except i; i, scale b.

Chelae of nearly the same size, with identical sculpture and exhibiting only slight differences in dentition of fingers. Large chela viewed laterally 3.5 times as long as broad with fingers occupying the distal 0.4. Inferior margin without grooves, superior margin marked by deep and narrow longitudinal groove between 2 sharp ridges running from dactylar articulation to end of palm. Distal shoulder on medial ridge more abrupt than on lateral ridge. Proximal to dactylus the groove extends laterally as a shallow depression for about half the width of the chela. Outer face without groove. Fixed finger of neotype broken but bearing 2 heavy teeth proximally that mesh with dactylus. Dactylus with one truncate tooth proximally, and 2 small rounded teeth near middle. Superior surface of dactyl bearing a brush of fine curving setae that extends three-fourths the length of the dactyl. Carpus cup-shaped, encompassing the base of the chela. Merus slender and unarmed, 2.4 times as long as broad. Dactylus of small chela proximally armed with heavy blunt tooth that fits between 2 on the fixed finger; distal to proximal teeth on fixed finger are 4 irregularly spaced, low rounded teeth; tips of fingers curved, acute and crossing. Carpus and merus similar to large chela.

Second leg with ratio 10: 2.0: 1.7: 1.7: 3.3.

Ischium of third leg 0.4 as long as merus, bearing on its inferior margin 2 movable spinules. Merus inermous, 8 times as long as wide. Carpus 0.5 as long as merus, propodus only a little longer than merus bearing 8 movable spinules on its inferior margin and 2 distally, proximal to dactylus. Dactylus conical, simple, almost 0.3 as long as propodus.

Telson 3.0 times as long as its posterior margin is broad. Proximal article of outer uropod bearing a rounded lobe on the transverse articulation.

Discussion: None of Stimpson's type specimens can be located in any American museum (see Banner, 1953: 34, and elsewhere) so a specimen from this collection has been selected as a neotype. While Green Cape, the locality for the neotype, is about 400 km away from Port Jackson, the type locality, the species ranges along the coast of New South Wales without great variation, and the Green Cape specimen is the largest and best preserved. Our specimens range in size from 11 mm to 19 mm with only minor differences. The rostrum was longer in relation to the orbital teeth in some; the breadth of the bases of the orbital teeth also varied (fig. 14a, c). Only 3 specimens had both chelae; in all 3 the chelae were symmetrical, but in one the small chela was about 10 per cent smaller than the large chela.

We believe Hale's specimen from Tasmania is definitely *A. trispinosus*. The rostrum in his figure appears extremely thin but we suggest this may be a poor drawing. *Alpheopsis* sp. (Banner & Banner, 1966a: 156) might also belong to this species, but, as the specimen was fragmentary, we hesitate to make a firm statement. The telson of this specimen agrees with that of the neotype.

It has been suggested several times (Hale, 1941: 266; Holthuis, 1951: 94; Banner & Banner, 1966a: 157) that *Alpheopsis* sp. De Man (1922: 24) from Indonesia was this species. However, we doubt this identity, for: (1) the anterior portion of the carapace is more projected; (2) the antennules are stouter; (3) the scaphocerite is shorter in relation to the antennules; and (4) the dactyl of the third leg is more slender and longer in relation to the propodus than the neotype. The dentition on the cutting surfaces of the fingers of the chelae are minimal compared to the neotype, but this is well known as a variable character, depending for the most part on age and sex. Finally, De Man states the telson is "0.98 mm long, 10 times as long as the distance between the postero-lateral angles, while the width at the base, 0.46 mm is almost half the length". In our specimens the telson is not more than 3.5 times as long as the posterior margin is broad. We (1966a: 157) have suggested that De Man's figures for the telson may be in error. De Man's specimen was only 8 mm long and apparently young, so its true status will have to await description of an adult form.

Coutière's specimens from the Azores furnished the material for many figures in *Les Alpheidae*, and we have compared our neotype with these figures. There are no obvious major differences between the Australian specimens and Coutière's from Azores, but until material from this region is compared with the Australian specimens there will still be question as to the true identity of Coutière's specimens.

On the basis of distributional pattern, we feel as we did in our 1966 paper that there may well be 3 species, one from the tropical Pacific, one from the south temperate Pacific, and another from the tropical and subtropical Atlantic.

Biological notes: Stimpson's specimen was taken from 6 fathoms. All of our Australian specimens were collected with trawls in water from 25–75 fms. De Man's specimen was taken from about 7 fms. Coutière did not state the depth of his specimens from the Azores, but Sollaud (1932: 376) reported specimens that were dredged near the Azores, presumably from deep water. *Alpheopsis* sp. Banner & Banner (1966a) from Samoa was collected intertidally.

Australian distribution: Stimpson's specimen came from Port Jackson, N.S.W., and Hale's from Tasmania. All of our specimens came from the coasts of New South Wales except for one specimen from South Australia.

General distribution: Until the true identity of De Man's, Coutière's, Sollaud's, and our specimens are confirmed, we are loath to ascribe any non-Australian distribution to this species.

Alpheopsis undicola sp. nov.

Fig. 15

Holotype: 10 mm male from coral head collected on outermost margin of the Great Barrier Reef on Opal Reef (AM P.18002). In area of normal violent wave action, in 5 ft of water.

Allotype: 11 mm female without chela from same locality as type (AM P.18003).

Description: Rostrum 1.8 times as long as broad, tip reaching past end of second antennular article. Orbital teeth similar but slightly shorter. Rostral front without grooves. Pterygostomial angle produced into small acute tooth. Antennular articles almost equal; second article a third wider than long. Stylocerite reaching slightly beyond end of second antennular article. Scaphocerite with strong lateral tooth reaching to end of antennular peduncle; squamous portion almost as long as lateral tooth. Carpocerite 2.8 times as long as broad, reaching past end of antennular peduncle. Basicerite with both superior and inferior lateral teeth acute and equal in development, reaching beyond middle of first antennular article.

Chelipeds nearly symmetrical, rounded and without grooves. Large chela 2.7 times as long as broad with fingers 0.4 as long as entire chela. Inferior margin concave opposite articulation of dactylus. Opposing surfaces of fingers bearing blunt teeth arranged close to medial face of appendage, lacking near tips; tips acute and crossing. Teeth on dactylus beset with short stiff setae on both sides, but teeth on

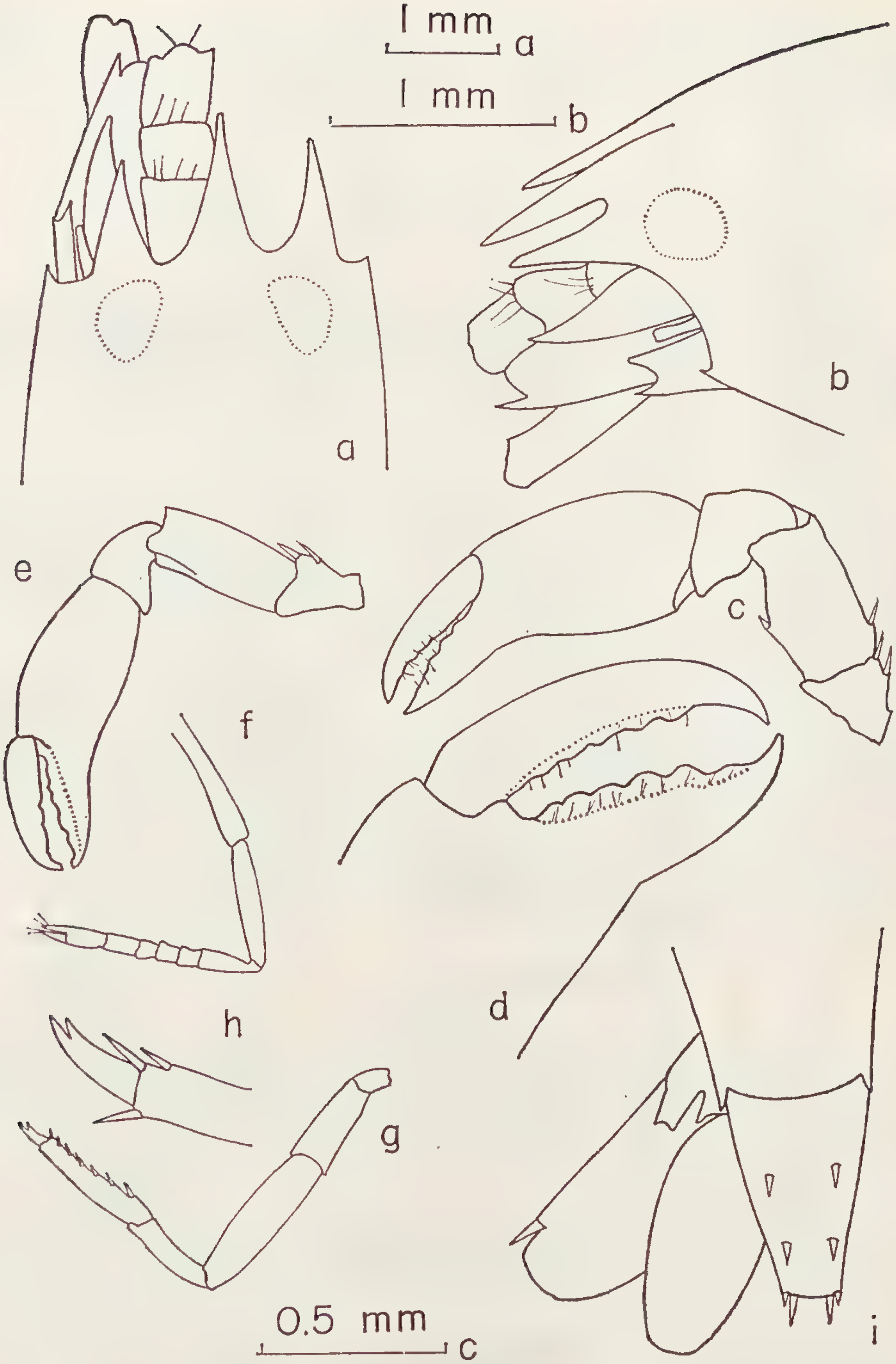


Figure 15.—*Alpheopsis undicola* sp. nov. a, b, anterior region of holotype, dorsal and lateral view; c, large cheliped, inner face; d, detail of fingers of large chela; e, small cheliped, inner face; f, second leg; g, third leg; h, dactylus of third leg; i, telson and uropods. c, e, f, g, scale a; a, b, d, i, scale b; h, scale c.

fixed finger with stiff setae only on outer side. Carpus cup-shaped, a little longer than broad distally. Merus of large cheliped heavy, 1.7 times as long as broad, infero-internal margin bearing a small strong spine near middle and heavy spine on proximal portion of superior margin, superior margin of ischium bearing 2 strong movable spines.

Small chela similar to large chela, but with less teeth on opposing surfaces of fingers. Merus 3.4 times as long as wide, inermous. Ischium similar to that of large cheliped.

Ratio of carpal articles of second leg: 10: 3: 3: 3: 5.

Ischium of third leg 0.6 as long as merus, unarmed. Merus 3.7 times as long as wide, inermous. Carpus as long as ischium, superior margin projecting as rounded tooth. Propodus as long as merus, bearing on inferior margin 8 movable spinules. Dactylus biunguiculate, with superior unguis curved and slightly longer than inferior unguis, ungui almost equal at base.

Telson 3.6 times as long as posterior margin is broad. Anterior margin 2.7 times as wide as posterior margin. Posterior margin very slightly arcuate.

Discussion: This species is related to the group of species in the genus *Alpheopsis* which bear orbital teeth. However, only *Alpheopsis diabolus* Banner of this group has both orbital teeth and the dactylus biunguiculate on the thoracic legs. In *A. diabolus* the dactyl of the large chela is twisted on its axis, and the orbital teeth are much shorter in relation to the rostrum than those of this species.

Biological notes: The two specimens, probably a pair, were collected when breaking up an encrusted head of dead coral in a location which, under normal weather conditions, bears the full brunt of the open ocean waves. (See Capt. James Cook's and Sir Joseph Banks' account of the near shipwreck of the *Endeavour* on this barrier a few hundred miles north.) Other species that are known to live in this zone are *Athanas rhothionastes* Banner & Banner (1960: 142) and species of the *Alpheus obesomanus* group throughout the Indo-Pacific.

The name is derived from Latin, meaning "one that lives below the waves".

Alpheopsis equalis Coutière

Fig. 16

Alpheopsis equalis Coutière, 1896, Bull. Mus. Hist. Nat., Paris, 2 (8): 382; 1905a, Fauna Geog. Mald. Laccad. 2 (4): 868, fig. 138. Armstrong, 1941, Am. Mus. Novit. (1137): 5, fig. 1, table X. Banner, 1953, Pacif. Sci. 7 (1): 15, fig. 4.

Alpheopsis equalis truncatus Coutière, 1903, Bull. Soc. Philomath., Paris IX, 5 (2): 89, figs 37, 38.

Alpheopsis consobrinus De Man, 1910b. Tijdschr. ned. dierk. Vereen. II, 11 (4): 305.

Specimens examined: 2 specimens from AM 73; 2, BAU 23; 1, BAU 47; 1, BAU 54.

Diagnosis: Rostrum narrow, triangular, reaching to end of first antennular article. Pterygostomial angle either acute or rounded. Antennular peduncle with articles subequal, but first article usually slightly the longest. Stylocerite reaching to near end of second antennular article. Scaphocerite as long as antennular peduncle, lateral spine a little longer than squamous portion. Carpocerite equal to antennular peduncles.

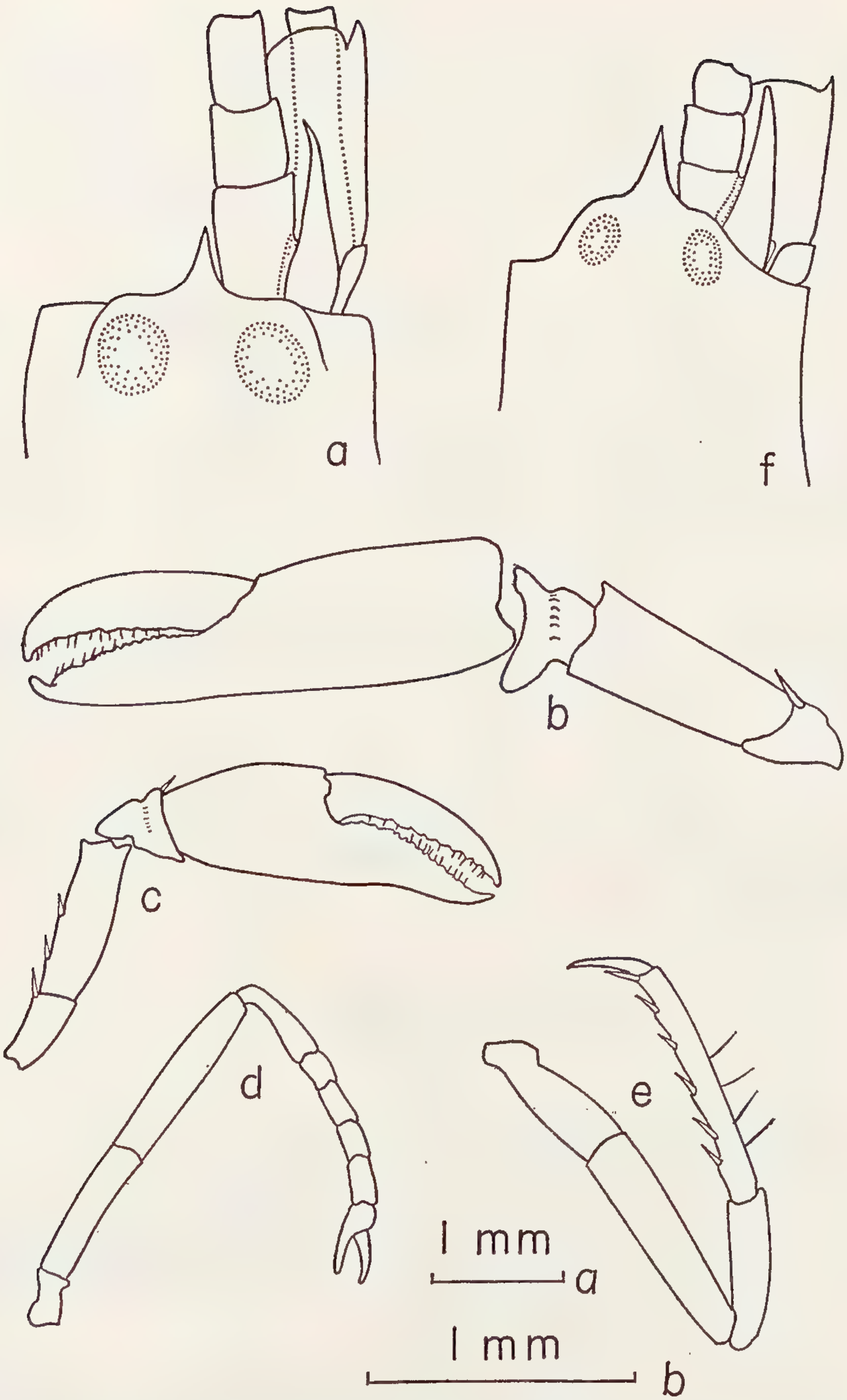


Figure 16.—*Alpheopsis equalis* Coutière. a, anterior region of 10 mm male from AM 73, dorsal view; b, large cheliped; c, small cheliped; d, second leg; e, third leg; f, anterior region of 12 mm male from BAU 23, dorsal view. b, c, d, e, scale a; a, f, scale b.

Cheliped at times symmetrical in size and shape, but usually showing about 10 per cent difference in size. Chelipeds of female similar to those of males, but about one-half the size. Fingers and palm of small chela almost equal in length, but in large chela palm longer than fingers. Opposing surfaces of fingers bearing slight irregular serrations or a series of variably shaped truncate teeth. Carpus elongate with outstanding flange into which proximal end of propodus fits, with slight constriction before this flange. Merus approximately 3 times as long as wide, bearing on its superior margin 2 or more spines; ischium also usually bearing movable spinules on superior margin.

Carpal articles of second legs with ratio: 10: 5: 5: 5: 6.

Third leg slender, merus 6.5 times as long as wide, dactylus simple; all articles unarmed except for propodus that bears about 6 strong spines.

Discussion: Of the six reasonably intact specimens in the collection there were 2 in which the rostrum reached well past the end of the first antennular article and the stylocerite reached to the end of the third article (see fig. 16f). The wide range of variation in many characteristics of this species has been discussed by Armstrong, 1941, and Banner, 1953; and we feel that when enough specimens of *A. equalis* are collected from Australia these specimens may fall within the range.

Biological notes: Our specimens were taken from dead coral broken off the reef flat in water not over 10 ft deep. Coutière reported that some specimens he collected at Djibouti (1898h: 198) were uniform orange in colour with the extremities of the chelae darker. Our specimens ranged in size up to 15 mm.

Australian distribution: This species has been collected only at Heron Island and Green Island, near Cairns.

General distribution: Israel, Red Sea, Maldive and Laccadive Archipelagoes, Philippines (to be reported), Fiji, Tonga, Samoa, Phoenix and Society Islands, and Hawaii.

Alpheopsis yaldwyni sp. nov.

Fig. 17

Holotype: 25 mm female collected by J. C. Yaldwyn, December, 1966, at One Tree Island, Capricorn Group, Qld. (AM P.18005.)

Paratypes: 1, 25 mm male and 1, 19 mm female, collected by Melbourne Ward, 1926, at Heron I., Capricorn Group (AM P.18006); 1, 25 mm ovigerous female and 1, 22 mm male collected at Heron I. by Julie Booth, 1965 (AM P.18007); 1, 22 mm female and 1, 18 mm male without chelae collected by A. P. McCulloch near Cooktown, Qld 8/10/06 (AM 298).

Diagnosis: Rostrum triangular, 1.5 times as long as broad at base, reaching to end of first antennular article. Carapace margin anterior to eyes and lateral to rostral base truncate, almost straight in dorsal view. Eyes concealed in dorsal and lateral view; carapace not inflated over eyes. Pterygostomial angle itself rounded, but margin of carapace slightly dorsal to angle produced into a short acute tooth.

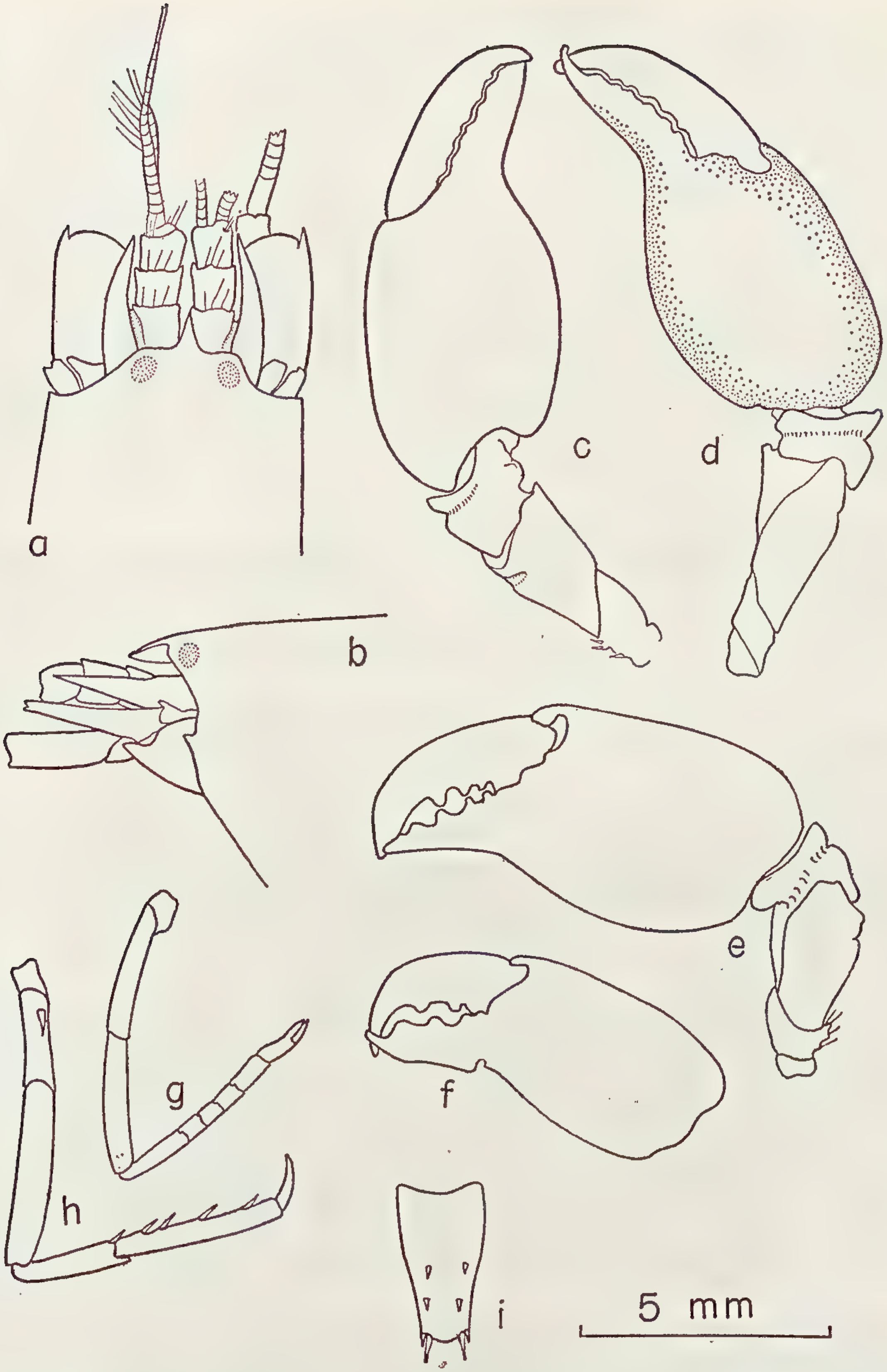


Figure 17.—*Alpheopsis yaldwyni* sp. nov. a, b, anterior region of holotype, dorsal and lateral view; c, large cheliped, inner face; d, large cheliped, outer face; e, large cheliped of paratype, 22 mm male from AM 390; f, large chela of paratype, 25 mm male from AM 283; g, second leg; h, third leg; i, telson.

Antennular peduncle thick, articles subequal, and each article about as broad as long. Stylocerite slender, acute, reaching almost to end of third antennular article. Scaphocerite reaching to end of stylocerite; lateral margin curved slightly inward distally, lateral spine a little longer than broad squamous portion. Carpocerite slightly longer than antennular peduncle. Inferolateral margin of basicerite projecting as a heavy blunt tooth.

Only one cheliped available in holotype. Chela 2.2 times as long as broad, with fingers 0.4 as long as entire chela. Palm of large chela inflated in lateral view, constricting on lower margin towards fingers. Palm without grooves, outer face convex, inner face completely flat; superior margin rounded, inferior margin knife-edged. Fingers 0.7 length of palm, slightly crossed at ends, opposing faces with 6 pairs of low rounded teeth which intermesh. Carpus heavy, broader than long; distally bearing superior transverse constriction or groove and expanding into collar around base of palm. Merus 2.2 times as long as broad, superior margin distally incised with groove continuing a short distance on adjacent face; distal margins of lateral and medial faces extended. Ischium bearing 3 short heavy spines on superior margin.

Carpal articles of second leg ratio: 10: 3: 3: 3: 4.

Third leg with ischium 0.4 as long as merus, proximally bearing strong spine. Merus 5 times as long as broad, inermous. Carpus 0.6 as long as merus, distally with a single spine on the inferior margin and rounded tooth on superior margin. Propodus 0.9 length of merus, bearing 5 spinules along inferior margin and 2 proximal to dactylus. Dactylus simple, conical, 0.3 as long as merus.

Telson 1.7 times as long as broad at its anterior end. Inner spine of posterolateral spines about 2.0 times as long as outer spine, outer spine the same size as those on dorsal surface.

Discussion: In the two paratypes from Heron Island collected by Miss Booth in 1965 there are two loose chelae—one exactly like the one which was attached to the holotype (fig. 17c) and one like we have figured (fig. 17e). This type of chela was also found attached to the 25 mm specimen collected by Mel Ward. This is not enough evidence to prove that fig. 17c is the typical female chela and that fig. 17e represents the male chela, but it suggests the possibility that there is sexual dimorphism in the chelae.

This species conforms well on almost all points to *Alpheopsis equalis* when the variability of that species is considered. The only important difference is the form of the large chela both in general configuration and in its unique flattened inner face. In *A. yaldwyni* the first carpal article of the second leg is 3 times the second, while in *A. equalis* it is never more than 2.3 times. However, this character is so variable we do not attach much importance to this difference. This species is also larger with 25 mm in length in the type as opposed to 15 mm, the largest *A. equalis* in our collection. The two specimens from Cooktown were without chelae and are therefore doubtful.

This species is named in honour of Dr John Yaldwyn, not only for the collection of the holotype, but also for the help and encouragement he has given to this study.

Biological notes: J.C. Yaldwyn made the following colour notes on this species in the field: "Body, hard, compact with 8 broad transverse bands of bright red. One across each antennular appendage, one across distal end of palm, one down carapace medially, across each leg, and one across tail". Miss Booth's field notes read, "red stripe, one per segment". All of the specimens were taken from broken-up coral heads from shallow water.

Genus **BETAEUS**

Betaeus Stimpson, 1861, Proc. Acad. Nat. Sci. Philad. 1860: 31.

Type species: Betaeus australis Stimpson.

Definition: Rostral front without rostrum or any teeth, rounded or depressed to varying degrees medially. Eyes completely covered by carapace. Pterygostomial angle rounded.

Stylocerite longer than first antennular article.

Chela rounded, showing slight asymmetry, carried in an inverted position with propodal finger uppermost. Chelipeds carried extended. Fingers often with heavy molar processes; often with simple arrangement of meshing teeth. Dentition various.

Second leg with carpus of 5 secondary articles.

Dactylus of third leg simple or biunguiculate. Merus usually with movable spinules proximally on outer face.

Pleura of sixth abdominal segment articulated. Males bearing *appendix masculina.* Telson with anal tubercles; posterior margin rounded.

Betaeus australis Stimpson

Fig. 18

Betaeus australis Stimpson, 1861, Proc. Acad. Nat. Sci. Philad., 1860: 31 [Port Jackson, N.S.W.]. Haswell, 1882, Cat. Australian Stalk and Sessile Eyed Crust: 192 [translation of Stimpson's description]. Hale, 1927, Crust. S. Australia, pt 1: 48.

Neotype: 21 mm non-ovigerous female from Long Reef, Collaroy, N.S.W. Collected from intertidal rock platform by J. C. Yaldwyn, 20/4/62 (AM P.18008).

Additional specimens: 2 specimens from AM 61; 1, AM 284; 1, AM 344; 3, AM 413; 1, AM 427; 1, AM P.4073; 2, AM P.4933; 1, AM P.5305; 4, AM P.6565; 9, AM P.6910; 15, AM P.6911; 1, AM P.7165; 1, AM P.9064; 1, AM P.10981; 4, AM P.11731; 1, AM P.13548; 1, AM P.13577.

Diagnosis: Anterodorsal margin of carapace extended and convex, with neither rostrum nor notch; eyes completely covered dorsally and laterally. First and second antennular article subequal in length; second article 1.6 times as long as broad; third antennular article 0.6 as long as second. Stylocerite slender, of uniform taper, reaching to middle of third antennular article. Squamous portion of scaphocerite reaching past end of antennular peduncle. Lateral spine a little longer than squamous portion and separated from it by a deep incision. Carpocerite a little longer than scaphocerite. Lateral spine of basicerite strong and acute. Pterygostomial angle rounded.

Chelae almost symmetrical, slightly compressed without sexual dimorphism, carried extended with dactylus in inferior position. One chela 3.8 the other 3.4 times as long as broad; fingers a little shorter than palm; inner surface of palm bears a small rounded tooth flanking the articulation of dactylus. Lower margin of palm bearing fine hairs forming a "brush". Large chela with cutting surface of both fingers bearing small rounded teeth almost the full length. Small chela (fig. 18e)

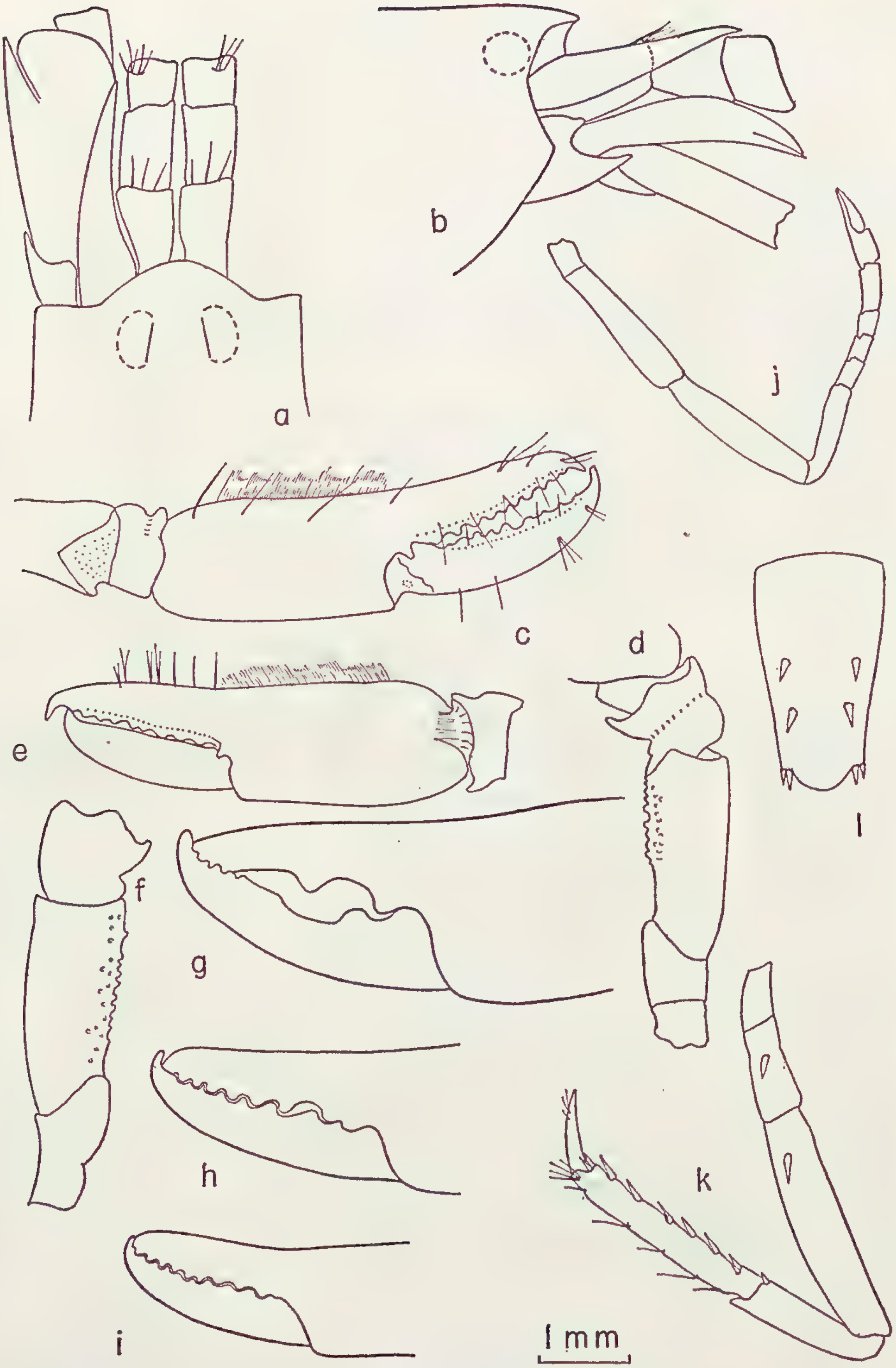


Figure 18.—*Betaeus australis* Stimpson. a, b, anterior region of neotype, dorsal and lateral view; c, large chela, inner face; d, merus and carpus of large chela, inner face; e, small chela, inner face; f, merus and carpus small chela, inner face; g, fingers of 27 mm male; h, fingers of 24 mm male; i, fingers of 25 mm female (g, h, i, from AM P.6910); j, second leg; k, third leg; l, telson.

with cutting margin of fixed finger bearing 10 small rounded teeth, opposing margin on dactyl not dentate. Tips of fingers of both chelae crossing. Carpus cup-shaped, 0.2 as long as chela, distal margin flared and encompassing base of chela. Distal margin bearing 2 strong rounded projections proximal to lateral sides of chela; between these 2 projections lies a smaller rounded projection. Merus 2.5 times as long as broad, inner face slightly papillose, inferointernal margin strongly papillose, appearing roundly serrate in profile. Inferior face bearing a triangular flattened portion on distal section which accommodates carpus when cheliped is flexed. Ischium unarmed and smooth.

Carpal articles of second legs with ratio: 10: 3: 3: 3: 5.

Third leg with spine on lateral face of ischium. Merus 5 times as long as broad and bearing spine proximally on its lateral surface. Carpus half as long as merus; superodistal margin produced into rounded tooth, inferodistal corner bearing small movable spine. Propodus slender, 0.8 as long as merus and bearing at least 6 movable spines on inferior margin, with fine setae adjacent to most spines. Superior margin also bearing several strong setae.

Pleura of sixth abdominal segment articulated.

Telson of usual form for family, 3.7 times as long as posterior margin is wide; anterior breadth 1.6 times as wide as tip; posterior margin strongly convex, posterolateral spinules not reaching level of distal margin.

Discussion: None of Stimpson's original type material is available (see *Alpheopsis trispinosus*, p. 339) and it is desirable to establish neotypes for his species. Stimpson's specimen came from Port Jackson and was 25 mm in length. Our specimen is smaller (21 mm), but we chose it because it was the best complete specimen we had from close to where Stimpson's specimen was collected.

In the neotype the antennules were deflected downward, thus in the drawings the scaphocerite and carpocerite appear a little longer than in the majority of specimens where the antennular peduncle is extended, making the scaphocerite and carpocerite more nearly the length of the peduncle. The stylocerite varied in length from the end of the second antennular article to the middle of the third article. In our 40 specimens the greatest amount of variation occurred in the dentition of the fingers of the chelae. We have figured 3 of the most common types (figs 18g, h, i), but occasionally we found a specimen in which both chelae were almost devoid of teeth. In the genus *Athanas* only the older and larger specimens bear the heavy irregular teeth, but in *B. australis* the development of the teeth could not be correlated with either size or sex. The roughness of the inner side of the meri of the chelipeds appeared to be influenced by age as the inner face of the large specimens were more strongly papillose than in the small specimens. In very large specimens the surface of the carpus was also rough.

Biological notes: This species is found intertidally under rocks. Our largest specimen was 35 mm long.

Stimpson states his specimen was green and Hale (1927: 48) states: "Upper surface rich purplish-brown; sides and tips of uropods white". J. C. Yaldwyn, who collected the neotype, supplied the following colour notes for it: "Dorsally purplish, laterally much lighter; transparent areas along back dorsally on each segment; hand reddish purple contrasting with the dark purple of the body; branchial region of carapace and lateral area of first few abdominal segments, as well as walking legs, virtually colourless. Purple colour due to dense mat of small, simple, stellate, red chromatophores with the whole area of red chromatophores surrounded by a mass of granular blue chromatophores extending a little beyond the red mat in places; anterodorsal part of the carapace is green with a mat of granular green chromatophores (similar in every way to the granular blue except for colour) on the dorsal half of the carapace; the eyes are black and clearly visible under the carapace hoods as the hoods are extending to the front of the carapace between the eyes. I am convinced that the red chromatophores are simple and not compounded with the blue. The white edge of the uropods which Hale (1927) mentions for this species is presumably the white setal fringe and not the appendage itself. This white fringe is quite obvious and shows no sign of colour".

Australian distribution: Our specimens, like Stimpson's, came mostly from the Sydney area. They were collected as far north as Yamba, N.S.W. One specimen was collected off Victoria, and Hale (1927: 48) reports it from South Australia. The species is apparently limited to south and southeastern Australia.

Genus **RACILIUS**

Racilius Paulson, 1875, Invest. Red Sea Crust., 1: 107.

Type species: Racilius compressus Paulson.

Definition: "The body is unusually compressed, in the form of a sheet [of cardboard] and has sharp edges on the abdominal segments; there is a crest on the cephalothorax which continues in a short rostrum. The eyes are covered by the spinous cephalothorax. The antennules have two flagella. Appendages, similar to those of *Alpheoides*, are present at the base of the pereiopods. The first pair of legs are the same length and equally strong and have giant chelae; their dactyli move in the vertical plane. The carpopodite of the second pair of legs is made up of five joints. The mandibles are like those of *Alpheus*. The anterior joint of the last maxilliped is not as short as that of *Alpheus*. The uropod is quite different from that of *Alpheus* and *Alpheoides*. This genus is closely related to the genera *Alpheus*, *Alpheoides*, *Arete* and *Betaeus*, forming a homogenous group with the subfamily of the *Alpheinae* with them." [Translated from the Russian by F. D. Por, 1961.]

To this description we should add that the pleura of the sixth abdominal segment are not articulated, and that in the type and only species the outer uropod bears a strong movable spine and on the inner uropod often a strong triangular projection.

We agree with both Paulson and Coutière (1899: 337) that this genus is near to *Alpheus* and was probably derived from it. The second leg bears five articles as is true of all *Alpheus;* the chela, though extremely compressed, has the general appearance and bears a plunger so typical of that genus.

Racilius compressus Paulson

Fig. 19

Racilius compressus Paulson, 1875, Recher. Crust. Mer Rouge, 107, pl. 14, fig. 2. Coutière, 1899, Les Alpheidae, 87, fig. 46; 243, fig. 296 [description and figures after Paulson]. Balss, 1927, Trans. Zool. Soc. Lond., 22 (2): 226. Barnard, 1958, Ann. Mag. Nat. Hist. XII, 10 (118): 732. Banner & Banner, 1966b, Siam Soc. Mono. No. 3: 159, fig. 62. Bruce, 1972. Crustaceana 22 (1): 91, 92.

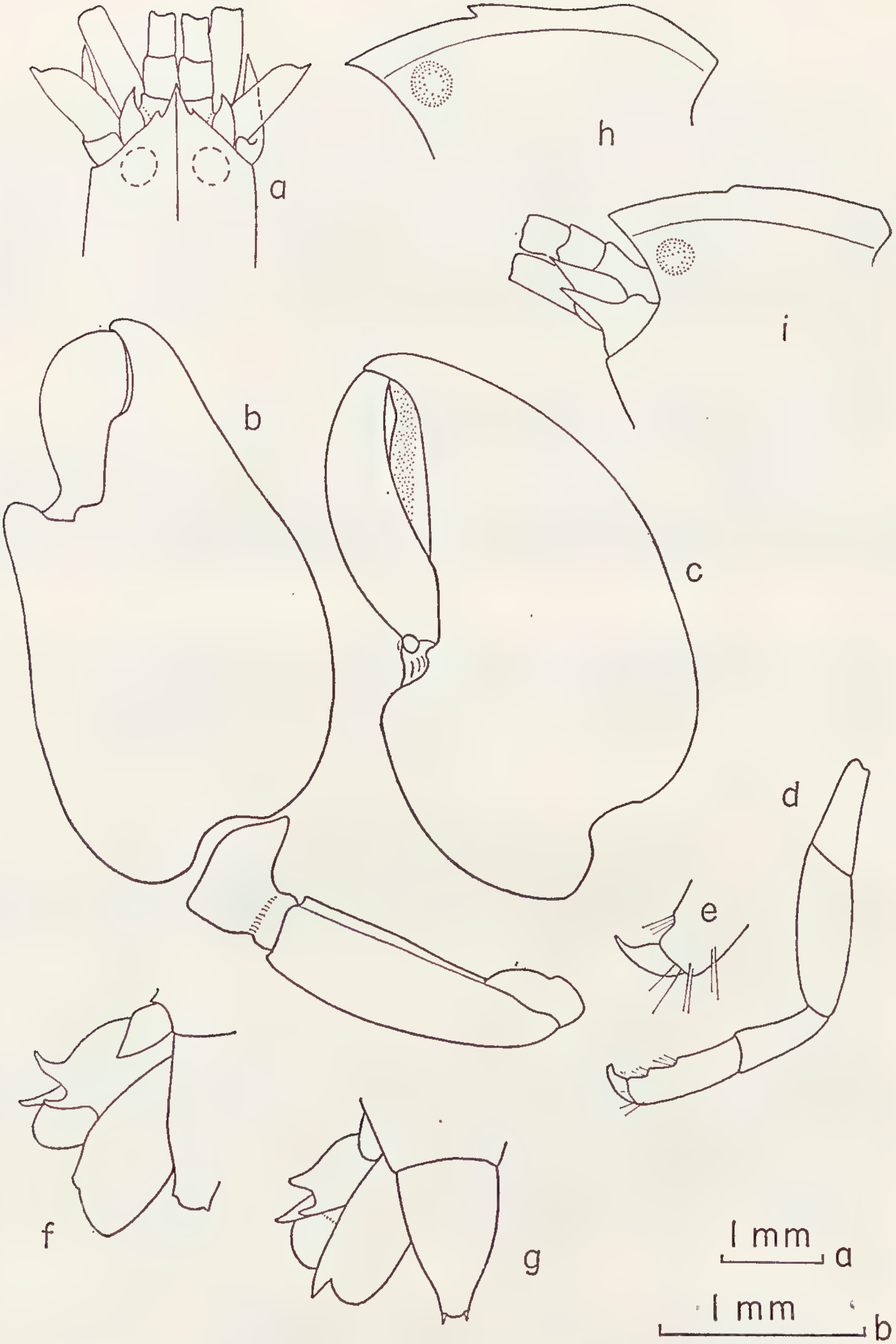


Figure 19.—*Racilius compressus* Paulson. a, anterior region of 15 mm female from AM 327, dorsal view; b, large cheliped; c, small cheliped; d, third leg; e, dactylus of third leg; f, telson; g, telson of 11 mm male from AM 327; h, lateral view of anterior region of 14 mm female from AM 337; i, lateral view of anterior region of 10 mm male from AM 337.

Specimens examined: 2 specimens from AM 327; 3, AM 337.

Diagnosis: Entire body and chelae with strong lateral compression. Eyes covered by carapace, but without inflated orbital hoods; with anterior orbital teeth. Rostrum broadly triangular, reaching to middle of second antennular article. Dorsal carina of carapace high and knife-like, extending from rostrum to posterior end of carapace; with variable notches. Stylocerite as long as first antennular article. Antennular articles short and thick. Scaphocerite reaching beyond end of second antennular article. Chelae similar in size, almost 1.6 times as long as broad, but on "large" chela, dactylus rounded and less than half as long as palm, while on "small" chela dactylus is curved and acute, equal to length of palm. Carpus expanded distally. Merus triangular in section, slender unarmed.

Carpal articles of second leg with ratio: 10: 2: 2: 1: 4.

Merus of third leg inermous, 2.6 times as long as broad. Propodus bearing distally on inferior margin one spine and a few setae, bearing proximally occasional patches of setae. Dactylus simple, broad at its proximal end, tapering abruptly to acute tip; tip so curved that it lies at a right angle to the propodus.

Telson strongly tapering, 6 times as long as posterior margin is broad. No movable spinules on upper surface. Posterior margin of proximal portion of outer uropod forms a flap bearing strong teeth with a large movable spine inserted between the two teeth. Distally outer uropod bears usual transverse articulation. Inner uropod with lateral margin projected into a triangular tooth of variable size, at times very small (fig. 19).

Discussion: The notch in the dorsal carina near the level of the eyes showed the usual variation in shape (19h, i; see also Banner & Banner, 1966b: 162). The variation in the lateral tooth on the inner uropod is described above (fig. 19f, g). About 25 specimens from a large collection of *R. compressus* from the Philippines exhibited the same variations.

Biological notes: All of our specimens were symbiotic on living coral of the genus *Galaxia;* all Australian specimens came from *G. vesiculatus.* We will report from the Philippines that it occurs in those species of *Galaxia* with closely-set polyps, occasionally in those with moderately-set polyps, and never in species with large, widely-set polyps. The lateral compression of the body and chelae allow the species to move about in the narrow spaces between the corallites. The body is transparent with a close scattering of minute red chromatophores. The eyes are blue-black and the female bears green eggs. (Colour notes supplied by J. C. Yaldwyn.) This species is usually small, but we had one specimen that was 15 mm.

Australian distribution: Our 5 specimens were collected on the reef flat on One Tree I. in the Capricorn Group.

General distribution: South and East Africa, Red Sea, Suez Canal, Singapore, Thailand, and the Philippines (the last to be reported on in a future paper).

APPENDIX

Locality Lists for the Alpheid Collection

In the listing given below are the localities and, at times, ecological notes for all specimens of all genera of the alpheids from Australia presently at hand. This, then, is the master listing for all three portions of the paper to be published. If additional specimens are obtained before the publication of the second and third parts of the paper, those listings will be added to Part 3. In an effort to keep the listing as short as possible, we have at times summarized the information on the labels of the specimens or referred back to an earlier listing.

The specimens came to us with a variety of designations, sometimes with museum catalogue numbers, either numerals alone or alphamerics, at other times without any coded reference. To shorten locality lists under the various species, and to facilitate the use of this master listing, we have prefaced each separate collection from an institution or an individual with a two to three letter code which is followed either by the official catalogue numbers or, where these were lacking, by numbers that we have assigned for this study. It may be presumed that if the institutions assign new catalogue numbers to the specimens that we have numbered, they will keep a cross-reference file.

In the listing below, the collections are arranged alphabetically by code designations. The codes are assigned as follows:

AC	Aquinas College.
AH	Allan Hancock Foundation.
AM	The Australian Museum, our assigned numbers.
AM E.	The Australian Museum, F.I.S. *Endeavour* Register numbers.
AM G.	The Australian Museum, General Invertebrate Register numbers.
AM P.	The Australian Museum, Crustacea Register numbers.
BAU	Banner, Australian collection.
CS	C. R. Smalley.
JB	John Boase.
JC	James Cook University.
MM	Macleay Museum.
QM	Queensland Museum.
QV	Queen Victoria Museum.
RG	R.U. Gooding.
SM	South Australian Museum, our assigned numbers.
SMC	South Australian Museum.
TM	Tasmanian Museum and Art Gallery.
UQ	University of Queensland.
US	United States National Museum.
VM	National Museum of Victoria.
WM	Western Australian Museum.

All specimens on loan will be returned to their institutions; we have indicated the repository of collections made by individuals.

COLLECTIONS FROM AQUINAS COLLEGE, MANNING

These collections, lent by the College, were made by students during yearly expeditions to the Houtman Abrolhos Islands off the coast of Western Australia. Their field numbers we have prefaced with "AC". These collections will be donated to the Western Australian Museum.

AC C–1. 1 mi. N. of Jubilee I. 19 fms. 4/1/68. Collected by scallop trawl, found in small cavities in coral and sponges. Coll. A. James and G. Davemport.

AC C–28. From small island S. of Gun I. 4 ft. 5/1/69. From living coral. Coll. A. James and G. Davemport.

AC C–29. 5 mi. N. of Rat I., in Easter Group. Collected by scallop trawl in 20 fms. 6/1/68. Sandy bottom. Coll. A. James and G. Davemport.

AC C–50, 54. E. side of Jubilee I. 4 ft. 7/1/68. On and in coral rocks on bottom. Coll. A. James and G. Davemport.

AC C–59. S. end of Pelsart I. 8/1/68. On and in coral rocks on bottom. Coll. A. James and G. Davenport.

AC S. 1. N. of Suomi I., in Easter Group. 3–4 ft. 23/8/70. Living on crinoid. Coll. G. Murphy.

AC S. 2. 3 mi. NW. of Basile I. 19 fms. 25/8/70. Dredged with scallop trawl. From living sponge. Coll. G. Murphy.

AC S. 3. 4 mi. N. of Gun I. 19 fms. 27/8/70. Coll. G. Murphy.

AC S. 4. 4 mi. N. of Gun I., Pelsart Group. 19 fms. 8/27/70.

AC S. 5. N. side of Wooded I., Easter Group. 3–4 ft. 27/8/70. From reef area, living on crinoid. Coll. G. Murphy.

COLLECTIONS FROM THE ALLAN HANCOCK FOUNDATION, LOS ANGELES, CALIFORNIA

AH Accession number 1968–11.

1. Heron I., Capricorn Group, Qld. Coll. Miss J. Haig, from *Acropora cunneata.*
2. Same as #1. Under rocks on exposed sand flat.
3. Same as #1. 11/6/68. From live *Pocillopora damicornis.*
4. Same as #1. 11/6/68. Outer reef flat from *Acropora.*
5. Same as #1. Coll. S. Domm. From *Pocillopora damicornis* in 15 ft of water over edge of reef.
6. Myora, Stradbroke I., Qld. Coll. Miss J. Haig, 27/6/68. Among oysters and under oyster clumps in mud and sand flat.

COLLECTIONS FROM THE AUSTRALIAN MUSEUM, SYDNEY

For collections not yet assigned a museum catalogue number we have assigned numbers prefaced with "AM"; the E, G, P series prefaced with "AM" are the museum register designations.

AM

1. Clovelly, near Sydney, N.S.W. 80 ft. Coll. N. Coleman, 1965. On sponges.
2. Heron I., Capricorn Group, Qld. J. S. Hynd collection. 27/5/47.
3. Off Ninety Mile Beach, between Cape Jaubert and Wallal, W.A. Dredged 5 miles off shore in 5 fms. Coll. A.A. Livingstone, Sept. 1929.
4. Gillet Cay, Swain Reefs, Qld. AM 1962 Swain Reefs Exped. Sta. 1, Oct. 1962. Under beach rock.
5. Geraldton, W.A. Coll. A. A. Livingstone, Oct. 1929. Intertidal, under rocks.
6. Lord Howe I., Tasman Sea, S. end lagoon. Coll. Miss J. Booth, 18/9/62.
7. Norman River mouth, Gulf of Carpentaria, Qld. Coll. D. F. McMichael and J. C. Yaldwyn, Dec. 1963.
8. Between Cape Bossutt and Broome, W.A. 5 fms. Coll. A. A. Livingstone, 11/9/29.
9. Cape Leveque, W.A. Coll. intertidal, coll. A. A. Livingstone, 20/8/29.
10. Between North and South Shell Is., Port Darwin, N.T. 3–7 fms. Coll. A. A. Livingstone, 15/7/29. Dredged among dead coral and sponges.
11. Fairlight, Manly, Port Jackson, N.S.W. Coll. Miss E. Pope, 1/2/64. Subtidal.

AM 12. Intertidal rock platform, Minnie Waters near Grafton, N.S.W. Coll. J. C. Yaldwyn, Feb. 1965.
13. Trawled off Karumba, Gulf of Carpentaria, Qld. 14 fms. Coll. J. C. Yaldwyn and D. F. McMichael on CSIRO prawn survey, Dec. 1963.
14. Same as AM 12.
15. Chambers Bay, Van Diemen Gulf, near Darwin, N.T. Taken from pearl shell growth by V. Wells off A. K. "Paxie" for A. A. Racek, Oct.–Nov. 1959.
16. Same as AM 11. 13/8/64.
17. Myora, Stradbroke I., Moreton Bay, Qld. J. S. Hynd collection, 8/3/46. From *Acropora* sp.
18. Thursday I., Torres Str., Qld.
19. Tale Head, Port Darwin, N.T. Coll. A. A. Livingstone, 24/6/29. Intertidal under stones.
20. Cape Leveque, W.A. Coll. A. A. Livingstone, 1929.
21. Same as AM 10.
22. Gantheaume Point, Broome, W.A. Coll. A. A. Livingstone, 5/8/29. Collected intertidally on reef under stones. Commensal on urchin *Heliocidaris tuberculata*.
23. Moreton Bay, Qld. American Fisheries Assoc.
24. Lord Howe I., Tasman Sea. Coll. Miss J. Booth, 27/2/63. Commensal on urchin *Heliocidaris tuberculata*.
26. Mary River Heads, Sandy Str., Qld. 2 fms. J. S. Hynd collection, 6/6/46. Commensal with an Alcyonarian.
27. Minnie Waters, near Grafton, N.S.W. Coll. J. C. Yaldwyn, 3/11/63. From intertidal rock platform.
28. Bountiful I., Gulf of Carpentaria, Qld. Coll. J. C. Yaldwyn, 30/11/63.
29. Heron I., Qld. Coll. L. R. Thomas, Oct. 1958.
30. Elliot River Heads, S. of Bundaberg, Qld. J. S. Hynd collection, 3/6/46.
31. Shelly Beach, Yamba, Clarence River mouth, N.S.W. Coll. A. A. Cameron from under stones below low tide mark.
32. Ship Rock, Little Turriell Point, Port Hacking, N.S.W. Coll. D. Wilson and party, 20/6/65.
33. Near entrance Roebuck Bay, Broome, W.A. 5–8 fms. Coll. A. A. Livingstone, 26/6/29. Lithothamnion ridge, reef bottom. [Inasmuch as the term "Lithothamnion Ridge" persists in the literature, but the algal ridge itself is composed mainly of alga known today as *Porolithon*, we have elected to retain the collector's name, but we do not italicize it as we would a proper generic name.]
34. Same as AM 3.
35. Entrance Roebuck Bay, Broome, W.A. 9 fms. Coll. by diver for A. A. Livingstone, 15/8/29.
36. Sandgate, Moreton Bay, Qld. J. S. Hynd collection, 27/7/46.
37. Same as AM 27. Feb. 1965.
38. Same as AM 36. 9/3/45.
39. Off Roebuck Bay, Broome, W.A. 5–9 fms. Coll. A. A. Livingstone, 1929.
40. Same as AM 35.
41. Long Reef, Collaroy, N.S.W. Coll. J. C. Yaldwyn, 21/4/63. From intertidal reef pools.
42. Same as AM 13.
43. Gillett Cay, Swain Reefs, Qld. Coll. by AM 1962 Swain Reefs Exped. Sta. 1, Oct. 1962. From broken coral from reef flat.
44. Same as AM 10.
45. Same as AM 8.
46, Long Reef, Collaroy, N.S.W. Coll. Miss E. Pope, 12/3/64. From intertidal platform.
47. Same as AM 10.
48. Gantheaume Point, Broome, W.A. Coll. A. A. Livingstone, Sept. 1929. Commensal with comatulid *Comanthus angulata*, intertidal.
49. Bottle and Glass Rocks, Port Jackson. N.S.W. Coll. Miss B. Campbell, 18/1/61.
50. Same as AM 33.
51. Manly, near Sydney, N.S.W. Coll. A. F. Basset-Hull.
52. Same as AM 43.
53. Same as AM 43, under beach rock.
54. Same as AM 48.
55. Off Broome Jetty, W.A. 4 fms. Coll. A. A. Livingstone, 16/8/29. Commensal on crinoids.
56. Scarborough, Moreton Bay, Qld. 2 fms. J. S. Hynd collection, 5/7/46. From weed.
57. Same as AM 22.

AM 58. Heron I., Capricorn Group, Qld.

59. Lord Howe I., Tasman Sea. Coll. Miss J. Booth, 18/9/62.

60. Same as AM 27.

61. Same as AM 51.

62. Same as AM 27.

63. Same as AM 10, 2/7/29.

64. West Cay, Diamond Islets, Coral Sea, Qld. Coll. J. C. Yaldwyn and D. F. McMichael, 23/10/63. From intertidal pools in beach rock.

65. South end lagoon, Lord Howe I., Tasman Sea. Specimens from dead coral.

66. Thursday I., Torres Str., Qld. Coll. M. Ward.

67. Same as AM 15.

68. Heron I., Capricorn Group, Qld. Coll. Outward Bound School Party, Dec. 1960. From coral reef.

69. Same as AM 27.

70. Scarborough, Moreton Bay, Qld. J. S. Hynd collection, 19/5/46. Trawled below low water mark.

71. Wistari Reef, Capricorn Group, Qld. J. S. Hynd collection, 2/6/47.

73. Heron I., Capricorn Group, Qld. Coll. Miss J. Booth, 2/7/63.

74. Same as AM 64. 7/11/64. From coral head washings.

75. Sellicks Beach, St Vincent Gulf, S.A. 10 ft below tide level, sargassum zone, 25/3/39.

76. Long Reef, Collaroy, N.S.W. Coll. Miss J. O. Campbell, 12/1/63. Under rocks.

77. Long Reef, Collaroy, N.S.W. Coll. Miss E. Pope, 22/10/57. Intertidal rock platform.

78. Ned's Beach, Lord Howe I., Tasman Sea. Coll. E. Pope, July 1959. Intertidal, among boulders.

79. Myora, Stradbroke I., Moreton Bay, Qld. J. S. Hynd collection, 27/10/46. From coral.

80. Heron I., Capricorn Group, Qld. Coll. Miss I. Bennett, 18/8/61.

81. Monkey I., Ross Creek, Townsville, Qld. Coll. W. McNae, 9/2/62.

82. Elliot Heads, S. of Bundaberg, Qld. J. S. Hynd collection, 3/6/46.

83. Same as AM 73.

84. Hopetoun, near Albany, W.A. Intertidal. CSIRO. Fisheries, 1947.

85. Same as AM 50.

87. Scamander, Tasmania. W. A. Haswell collection.

88. Heron I., Capricorn Group, Qld. Coll. H. Cogger, 1956. From coral reef.

89. Same as AM 73.

90. Thomas Cay, Swain Reefs, Qld. Coll. L. R. Thomas, Nov. 1960. From coral on reef.

91. Off Gillett Cay, Swain Reefs, Qld. Dredged in 20 fms. AM 1962 Swain Reefs Exped. Sta. 4, Oct. 1962.

92. Townsville, Qld. Coll. W. McNae, March 1962. From mangrove swamp.

93. Lord Howe I., Tasman Sea. Coll. Miss J. Booth, Sept. 1962.

94. Lady Elliot I., Qld. Coll. Mrs C. Wright, 1964.

96. Barron River, Cairns, Qld. Coll. B. Campbell, 6/11/63. Downstream from road bridge. Salinity at low water was c. 90/00. 3 ft below surface of river bank at water table, within meshwork of interconnecting *Sesarma* crab burrows and chambers.

97. Pearl Shoals, off Broome, W.A. Coll. A. A. Livingstone, 14/9/29. On disc of crinoid *Comanthus* sp.

98. Kenn Reef, Coral Sea, Qld. Coll. D. F. McMichael, 2/10/60.

99. Endeavour River, Cooktown, Qld.

101. Moonta Bay, Spencers Gulf, S.A. Coll. K. Sheard.

102. Karumba, Gulf of Carpentaria, Qld. Trawled in less than 14 fms. Coll. D. F. McMichael and J. C. Yaldwyn, Dec. 1963 during CSIRO prawn survey. Commensal on "cow udder" sponge.

103. Same as AM 87.

104. Heron I., Capricorn Group, Qld.

105. Same as AM 104.

106. Same as AM 43.

107. Same as AM 43.

108. Same as AM 104.

109. North East Cay, Herald Group, Qld. Coll. J. C. Yaldwyn, 9/11/63. From coral washings.

110. Tyroom Roads, Sandy Str., Qld. 10 fms. J. S. Hynd collection, 6/6/46. From alcyonarian.

112. South Bank, Pancake Channel, Port Curtis, Qld. J. S. Hynd collection, 25/8/46. Under living coral, on dead coral.

AM 113. Seal Rocks, Port Curtis, Qld. J. S. Hynd collection, 28/8/46.
114. Gulf of Carpentaria, 17° 24.7′ S., 140° 31.7′ E., CSIRO Prawn Survey. Sta. 19, 5 fms, 2/8/63.
114a. Sandgate, Moreton Bay, Qld. J. S. Hynd collection, 25/6/44.
115. Norfolk I., Tasman Sea. Coll. Mrs L. March, Oct. 1960.
116. Shark Bay, W.A. Collected by CSIRO Fisheries, 27/9/48. Trawled from sponges.
117. Scarborough, Moreton Bay, Qld. J. S. Hynd collection, 3/9/45. From weed flat.
118. Shoals light buoy, off Cape Moreton, Qld. 11 fms. Coll. J. S. Hynd on S.S. *Cape Leeuwin*.
119. The Brook, Lord Howe I., Tasman Sea. Coll. Miss J. Booth, 3/6/62.
120. Same as AM 43.
121. Albany Passage area, Torres Str., Qld. Coll. M. Ward, Sept. 1928.
122. Two Fold Bay, Eden, N.S.W. W. A. Haswell collection.
123. Same as AM 104.
124. West Side, Fort Hill Point, Darwin, N.T. Coll. A. A. Livingstone, 1929. Intertidal.
125. Same as AM 102.
126. Elliot Heads, S. of Bundaberg, Qld. J. S. Hynd collection, 3/6/46. Under stones.
127. Proulee Beach, 1/2 miles from footbridge, South Coast, N.S.W. Coll. R. E. Barwick, 14/5/62.
128. Cape Leveque, W.A. Coll. A. A. Livingstone, 19/8/28. Intertidal.
129. Same as AM 27.
130. Off Mary River, North Head, Sandy Str., Qld. J. S. Hynd collection, 6/6/46. From sandy mud flat.
131. Same as AM 27, Feb. 1965.
132. Woody Head, Clarence River mouth, N.S.W. Coll. A. A. and M. Cameron, 28/8/65. Intertidal.
133. Same as AM 79, 27/3/46. From outer sandbank.
134. Same as AM 9.
135. Lord Howe I., Tasman Sea. Coll. Miss J. Booth, Nov. 1962. Found in coral south end of lagoon.
136. Same as AM 102.
137. Same as AM 10. 4/7/29.
138. Same as AM 48.
139. Entrance to Roebuck Bay, Broome, W.A. 9 fms. Coll. by diver for A. A. Livingstone, 15/8/29.
140. Same as AM 10. 2/7/29.
141. Same as AM 50.
142. Lady Elliot I., off Bundaberg, Qld. Coll. Mrs C. Wright, 1964.
143. Hook Reef, Great Barrier Reef, E. of Whitsunday Passage, Qld. Coll. F. A. McNeill, July 1962.
144. Reef Point, Scarborough, Moreton Bay, Qld. Coll. J. S. Hynd, 17/4/47. Intertidal rock pools.
145. Same as AM 110.
146. Same as AM 41.
147. Same as AM 104.
148. Angourie, mouth of Clarence River, N.S.W. Trawled in 18 fms. Pres. A. A. Cameron, Sept. 1963.
149. Albatross Bay, near Weipa, Gulf of Carpentaria, Qld. Dredged. Coll. H. Foley, 1962–63.
150. Same as AM 27.
151. Same as AM 20.
152. Same as AM 27.
153. Port Curtis, Qld. J. S. Hynd collection, August 1916.
154. Same as AM 102.
155. Same as AM 43.
156. Same as AM 43, sta. 2.
157. Same as AM 43.
158. Same as AM 41, 2/1/64.
159. Roebuck Bay, Broome, W.A. Coll. A. A. Livingstone, Sept. 1929. From tidal flat.
160. Same as AM 15.
162. Mangrove Creek, just south of Ross River, Townsville, Qld. Coll. W. MacNae, March 1962.
163. Gillett Cay, Swain Reefs, Qld. Dredged from 20 fms. Coll. J. C. Yaldwyn with Australian Museum 1962 Swain Reefs Exped. Sta. 4.
164. Jacob's Well, S. end Moreton Bay, Qld. J. S. Hynd collection, 10/5/42.

AM 165. Same as AM 79, 22/5/45.

167. Pancake Channel, Bustard Head, Port Curtis, Qld. J. S. Hynd collection, 25/8/46. Intertidal pools.

168. Green I., off Cairns, Qld. J. S. Hynd collection, 14/7/46.

169. Same as AM 102.

170. Same as AM 43.

171. West Cay, Diamond Islets, Coral Sea, Qld. Coll. J. C. Yaldwyn and D. F. McMichael, Oct. 1963.

172. Mouth of Norman River, Gulf of Carpentaria, Qld. Coll. D. F. McMichael and J. C. Yaldwyn, 16/12/63. From burrows in intertidal mud flats.

173. Same as AM 102.

174. Same as AM 43, 13/10/62.

175. Manly, Moreton Bay, Qld. J. S. Hynd collection, 27/7/46. From weed.

177. Off Cape Varquar, between North West Cape and Shark Bay, W.A. CSIRO Fisheries, 12/11/48.

179. Scarborough, Moreton Bay, Qld. J. S. Hynd collection, 17/9/45.

180. Gulf of Carpentaria, 17° 5.7′ S., 140° 30.0′ E., CSIRO Prawn Survey. Sta. 805, 8 fms, 24/4/64.

182. NE. up Rainbow Channel from Myora Light, Stradbroke I., Moreton Bay, Qld. Dredged in coarse sand, 6–8 fms. Coll. W. Stephenson, 12/10/61.

183. Same as AM 102, Sta. 55.

184. Townsville, Qld. W. A. Haswell collection.

185. Same as AM 27.

186. Heron I., Capricorn Group, Qld. Coral reef. Coll. Outward Bound School Party, Dec. 1960.

187. Same as AM 144, 8/12/46.

188. Same as AM 102.

189. Same as AM 27.

190. Entrance Point, Broome, W.A. Coll. A. A. Livingstone, 1929. From intertidal region on rocky reef shore.

191. Same as AM 3.

192. Same as AM 41. 20/4/62.

193. Gulf of Carpentaria, 17° 21.4′ S., 139° 53.0′ E., CSIRO Prawn Survey. Sta. 78, 6 fms, 21/8/63.

194. Southern Gulf of Carpentaria, NE. of Albert River, Qld. 14 fms. CSIRO Prawn Survey. Coll. D. F. McMichael, Dec. 1963.

195. Port Jackson, N.S.W. W. A. Haswell collection.

196. Heron I., Capricorn Group, southern Barrier Reef, Qld. Coll. J. A. Bishop, 9/1/61. From broken coral on reef flat.

197. Same as AM 142.

198. Bountiful I., Gulf of Carpentaria, Qld. Coll. J. C. Yaldwyn, Dec. 1963. From intertidal rock platform.

199. Same as AM 15.

200. Same as AM 40.

201. Heron I., Capricorn Group, Qld. Coll. K. Gillett, Dec. 1960. From reef flat.

202. Barron River, Cairns, N. Qld. Coll. J. C. Yaldwyn, 2/11/63. From *Sesarma* crab burrows deep within river bank. Same loc. as AM 96.

203. Entrance Point, Broome, W.A. Coll. A. A. Livingstone, Aug. 1929. Intertidal rocky reef shore.

205. South end lagoon, Lord Howe I., Tasman Sea. From dead coral.

206. Norman River Mouth, Karumba, Gulf of Carpentaria, Qld. Coll. J. C. Yaldwyn, Dec. 1963.

207. Same as AM 79. 28/9/46.

208. Same as AM 159. 8/8/29.

209. Lady Elliot I., off Bundaberg, Qld. Coll. Mrs C. Wright, 1964.

210. Same as AM 27.

211. Lord Howe I., Tasman Sea. Coll. Miss J. Booth, 6/3/63.

212. Long Reef, Collaroy, N.S.W. Coll. Miss I. Bennett, May 1964. Intertidal, under rocks.

213. North of Norman River, Gulf of Carpentaria, Qld. Coll. D. F. McMichael and J. C. Yaldwyn, Dec. 1963. Under intertidal beach rock boulders.

214. Off Cape Moreton, Qld. Trawled 11 fms. S.S. *Cape Leeuwin*, J. S. Hynd collection.

215. Same as AM 41, 20/4/62.

216. Same as AM 27, Feb. 1965.

217. Same as AM 216.

AM 218. Same as AM 112. Upper part of intertidal zone.

219. North East Cay, Herald Group, Coral Sea. Coll. J. C. Yaldwyn and D. F. McMichael. 7/11/63. Under beach rock.

220. Shark I., Port Jackson, N.S.W. 9/11/08.

221. Same as AM 43.

222. Same as AM 216.

223. Same as AM 211, 27/2/63.

224. Same as AM 50.

225. Ned's Beach, Lord Howe I., Tasman Sea. Coll. D. Linklater, March 1967. Intertidal under rocks, commensal among spines on under side of *Heliocidaris tuberculata*.

226. Same as AM 171, 23/10/64.

227. Same as AM 168.

228. Same as AM 20, 19/8/29.

229. Jervis Bay, N.S.W. Dredged, 25/1/31.

230. Long Reef, Collaroy, N.S.W. Coll. Miss I. Bennett, 27/7/62. Intertidal.

231. Same as AM 79.

232. Long I., Whitsunday Group, Qld. Coll. F. A. McNeill, July 1962.

233. Same as AM 27.

234. Same as AM 213.

235. Lord Howe I., Tasman Sea. Coll. Miss J. Booth, March 1962.

236. Off Mary River Heads, Sandy Str., Qld. Trawled, 2 fms. J. S. Hynd collection, 6/6/46.

237. East Point, near Point Darwin, N.T. Coll. A. A. Livingstone, 3/7/29. Intertidal.

238. Heron I., Capricorn Group, Qld. Coll. Sydney Univ. Zool. Dept., Aug. 1960.

239. Entrance Point, Broome, W.A. Coll. A. A. Livingstone, Aug. 1929.

240. Hayman I., Whitsunday Group, Qld. Coll. Miss B. Campbell, 28/10/60.

241. Black Ned's Bay, Lake Macquarie, N.S.W. CSIRO Fisheries Survey, 27/9/65. Silt and *Zostera*.

242. Same as AM 41.

243. Same as AM 104.

244. Same as AM 79.

245. 1 mi. NE. Seal Rocks, Port Curtis, Qld. 7–8 fms. J. S. Hynd collection, 2/9/46.

246. Bustard Head, Port Curtis, Qld. J. S. Hynd collection, 28/8/46. Intertidal rocks.

247. Same as AM 102.

248. Off Gantheaume Point, Broome, W.A. Dredged 4 fms. Coll. A. A. Livingstone, Aug. 1929.

249. Heron I., Capricorn Group, Qld. Coll. Miss I. Bennett, Aug. 1961.

250. Thursday I., Torres Str., Qld. Coll. Miss B. Campbell, 16/10/60.

251. Same as AM 102.

252. Off Heron I., Capricorn Group, Qld. 20 fms. Coll. K. Gillett, 1959.

253. Scarborough, Moreton Bay, Qld. J. S. Hynd collection, 8/12/46. Under rocks.

254. Long Reef, Collaroy, N.S.W. Coll. J. C. Yaldwyn, 27/1/64. Intertidal.

255. Quail I., about 35 mi. W. from Port Darwin, N.T. Coll. A. A. Livingstone, 8/7/29. Intertidal on coral reef.

256. Port Jackson, N.S.W. W. A. Haswell collection.

257. Off Gillett Cay, Swain Reefs, Southern Barrier Reef, Qld. Australian Museum 1962 Exped. Sta. 6. Dredged from 36–40 fms. Oct. 1962.

258. Dredged W. side of South Shell I., Port Darwin, N.T., about 25 yds off shore. Dredged 5 fms. Coll. A. A. Livingstone, 24/7/29.

259. Same as AM 10, 4/7/29.

260. Same as AM 181.

261. Same as AM 41.

262. Trawled Shark Bay, W.A. CSIRO Fisheries, 21/9/48. From sponges.

264. Ned's Beach, Lord Howe I., Tasman Sea. Coll. Miss J. Booth, Oct. 1962.

265. East Point, Port Darwin, N.T. Coll. intertidal, 22/6/29.

266. Long Reef, Collaroy, N.S.W. Coll. A. Healy, 20/12/64.

267. Same as AM 41, 27/1/64.

268. Off Solitary I., near Wooli, Grafton Area, N.S.W. Coll. G. Biddle, 1964. From living coral head.

269. Glacier Point, Port Hacking, N.S.W. 2–4 fms. Coll. C. Lawler, 20/11/64. Associated with urchin *Centrostephanus rodgersii* in excavation in rock.

270. Watson's Bay, Port Jackson, N.S.W. Coll. F. E. Grant.

271. Same as AM 41, 2/1/64.

272. Minnie Waters, near Grafton, N.S.W. Intertidal rock platform. Coll. G. Biddl and A. Healy, Dec. 1964.

AM 273. Dredged off Shark I., Port Jackson, N.S.W. W. A. Haswell collection, 25/9/15.
274. Cape Don, Darwin, N.T. Coll. Miss E. Pope, 17/10/65. On reef.
275. North West I., Capricorn Group, Qld. Coll. M. Ward and W. Boardman, July 1929.
276. Same as AM 275.
277. SE. corner, Gulf of Carpentaria, Qld. CSIRO Prawn Survey 1963–65. Caught on mud flats of Norman River at Karumba.
278. Port Curtis, Qld. Coll. M. Ward, 1930.
279. Edge of creek near Sander's Beach about 20 mi. north of Townsville, Qld. Coll. W. Macnae, 17/3/62. Edge of *Rhizophora* fringe.
280. Dredged off Gatcombe Head, Facing I., Port Curtis, Qld. 9–12 fms. Coll. M. Ward, Dec. 1929.
281. Fannie Bay rocks, Darwin, N.T. Coll. Miss E. Pope and J. Boase, 11/10/65.
282. Same as AM 275.
283. Heron I., Capricorn Group, Qld. Coll. M. Ward, 1926.
284. Long Reef, Collaroy, N.S.W. Coll. J. C. Yaldwyn. Intertidal.
285. East Point, Darwin, N.T. Coll. Miss E. Pope and J. Boase, 25/10/65. Intertidal.
286. Dredged off Peak Point, Cape York, Torres Str., Qld. 3–6 fms. Coll. M. Ward, 31/8/28.
287. SE. corner, Gulf of Carpentaria, Qld. CSIRO Prawn Survey Trawl Stn. 555. 17° 24′ S., 140° 42′ E. 2 1/2 fms. 16/1/64.
288. Trawled off Yamba, near Clarence River mouth, N.S.W. Coll. G. Biddle, May 1965.
289. Long Reef, Collaroy, N.S.W. Coll. Miss E. Pope, Oct. 1965.
290. One Tree I., Capricorn Group, Great Barrier Reef, Qld. Coll. Museum Party, 25/9/65. Coral reef stn. Ft. 30.
291. Same as AM 277.
292. Darwin Power House screens, Darwin, N.T. Coll. Miss E. Pope, 22/10/65.
293. Cape Don, N.T. Coll. Miss E. Pope and party, 17/10/65. Under stones and in crevices.
294. Same as AM 283.
295. Same as AM 277.
296. Dredged D'Entrecasteaux Channel, Tasmania. 5 fms. Coll. M. Ward, Oct. 1929. On scallop banks.
297. SE. corner, Gulf of Carpentaria, Qld. Norman River at Karumba. CSIRO Prawn Survey, 10/2/64.
298. Hope I., near Cooktown, Qld. Coll. A. R. McCulloch, Aug. 1906.
299. Same as AM 275.
300. Port Curtis, Qld. Coll. M. Ward, 1930.
301. Fannie Bay rocks, Darwin, N.T. Coll. Miss E. Pope, Oct. 1965. Intertidal.
302. North West I., Capricorn Group, Qld. Coll. M. Ward, May 1930.
303. Same as AM 286, 1/9/28.
304. Same as AM 301, 12/10/65.
305. Murray I., Torres Str., Qld. Coll. C. Hedley and A. R. McCulloch, Aug.–Oct. 1907.
306. Same as AM 280. July 1929.
307. Same as AM 286.
308. Stokes Hill Power Station screens, Darwin, N.T. Coll. Miss E. Pope, 22/10/65.
308a. SE. Gulf of Carpentaria, Qld. CSIRO Prawn Survey 1963–65. From sponge.
309. Rat I., Port Curtis, Gladstone, Qld. Coll. M. Ward and W. Boardman, July 1929.
310. Three Mile Creek between Townsville and Cape Pallerenda, Qld. Coll. W. McNae, 7/12/62. From sand mud in islet in creek.
311. Michaelmas Cay, Capricorn Group, Great Barrier Reef, Qld. Poison St. Coll. F. H. Talbot and Museum party, 16/10/65.
312. SE. corner, Gulf of Carpentaria, Qld. CSIRO Prawn Survey trawl Sta. 606. 16° 29′ S., 141° 02′ E. 2 fms. 18/2/64.
314. Dredged Albany Passage Area, Torres Str., Qld. 9–12 fms. Coll. M. Ward, Sept. 1928.
315. Low Isles, near Port Douglas, Qld. Great Barrier Reef Exped. Coll. Iredale, McNeill, Livingstone. Oct. to Nov. 1928.
316. One Tree I., Capricorn Group, Qld. Coll. J. C. Yaldwyn and Museum party, Dec. 1966.
317. One Tree I., Capricorn Group, Qld. Among piecrust and sand, lagoon.
318. Same as AM 316. From broken coral, lagoon shallows, Dec. 1966.
319. Same as AM 316. On outer reef space. From living coral and lithothamnion surface about 12 ft deep.
320. Same as AM 316.

AM 321. Same as AM 316. Among living corals on sandy bottom of lagoon, shallow water, Nov. 1966.

322. Same as AM 316.

323. Same as AM 321.

324. Same as AM 316. Lagoon, in *Halimeda* and mixed weed in "bombies" and piecrust near southern tip of reef, 1 mile from island. Coll. M. Cameron and D. J. Griffin, 7/10/67.

325. Same as AM 316.

326. Same as AM 316. From broken piecrust, transect B. Nov. 1966.

327. Same as AM 326. From large head of *Galaxea vesiculatus* from lagoon.

328. Same as AM 316. 6 ft FT 202, outer southern face of reef, near island from *Acropora* sp. Coll. F. H. Talbot and party, 28/9/67.

329. Same as AM 328. 10 ft. 29/9/67.

330. Same as AM 316. From living coral. 18/11/66.

331. Same as AM 318.

332. Same as AM 316. From algal mat, lagoon shallows.

333. Same as AM 316. 20 ft. FT 205. Outer southern face of reef, near island. Coll. F. H. Talbot and party, 23/9/67.

334. Same as AM 316. From broken coral piecrust, lagoon near island, transect B., Nov. 1966.

335. Same as AM 332.

336. Same as AM 332.

337. Same as AM 327.

338. Same as AM 321.

339. Same as AM 321.

340. Same as AM 324. Reef crest in *Halimeda* and mixed weed and under stones, NW. face, low tide. Coll. M. Cameron and D. J. Griffin, 9/10/67.

341. Same as AM 334.

342. Same as AM 334.

343. Same as AM 334.

344. Long Reef, Collaroy, N.S.W. Coll. I. Smith, 16/7/67. In rock pool.

345. Darwin, N.T. Coll. B. McCann, 1966.

346. Minnie Waters, near Grafton, N.S.W. Coll. G. Biddle early in 1967 from intertidal rock platform.

347. Port Hacking, N.S.W. Coll. G. Lewin, 1966. Taken with bait prawns.

348. Hunter River between Newcastle Harbour and Raymond Terrace, N.S.W. Coll. N. Ruello and J. C. Yaldwyn, 2/11/67. Prawn trawl from mud bottom.

349. Same as AM 346.

350. Wellington Point, Brisbane, Qld. Coll. E. F. Reik, 30/8/60.

354. Same as AM 102.

356. Hunter River, between Newcastle Harbour and Raymond Terrace, N.S.W. Coll. N. Ruello and J. C. Yaldwyn, 2/11/67.

382. Off Doole I., in Gales Bay, Exmouth Gulf, W.A. 12 ft. Coll. I. Monro, 7/9/66. CSIRO Survey, Sta. 4.

383. Off Headland, Quarantine Bay, North Head, Sydney Harbour, N.S.W. Museum party 5/4/67. Shallow water.

384. Stradbroke I., Moreton Bay, Qld. Subtidal, Sept.–Oct. 1968. From yellow crinoid.

385. Same as AM 27, May 1967.

386. Careel Bay, Pittwater, near Sydney, N.S.W. Coll. J. C. Yaldwyn and A. Healy, 26/10/68.

387. 2 mi. off mouth of Yardi River, NE. of Onslow, W.A. 23 ft. CSIRO Survey, 13/9/66. Commensal on crinoid. Coll. I. Monro.

388. Bottle and Glass Rocks, Sydney Harbour, N.S.W. Coll. J. C. Yaldwyn and party, 29/11/68.

389. Ashburton River north of Exmouth Gulf, W.A. Coll. I. Monro, CSIRO Survey.

390. Heron I., Capricorn Group, Qld. Coll. Julie Booth, 1965.

391. Strand, near Queens Hotel, Townsville, Qld. Coll. D. R. Fielder, Oct. 1966.

392. Gillett Cay, Swain Reefs, Qld. Australian Museum Swain Reefs Exped. 20/10/62. From crinoid.

393. Long Reef, Collaroy, N.S.W. Coll. J. Holloway, 5/9/67.

394. One Tree I., Capricorn Group, Qld. 40 ft. Coll. J. C. Yaldwyn, 28/11/66. From lemon-yellow comatulid (Sta. FT 97).

394a. East Point, Darwin, N.T. Coll. E. Pope, Oct. 1965. Among arms of dark crinoids.

395. Intertidal rock platform, Long Reef, Collaroy, N.S.W. Coll. A. Healy, 1/1/68.

396. Long Reef, Collaroy, N.S.W. Coll. J. C. Yaldwyn and party, 21/11/68. On reef flat.

AM 397. Dredged 2 mi. NE. of Gillett Cay, Swain Reefs, Qld. 38 fms. Australian Museum Swain Reefs Exped. Stn. 6.
398. Same as AM 396.
399. Same as AM 395, 3/11/67.
400. Same as AM 317, Nov. 1966.
401. Scarborough, Moreton Bay, Qld. J. S. Hynd collection, 17/9/45.
402. Manly, Moreton Bay, Qld. J. S. Hynd collection, 27/7/46. From weed.
403. Off Mary River Heads, Sandy Str., Qld. J. S. Hynd collection, 6/6/46.
404. Lord Howe I., Tasman Sea. Coll. Miss J. Booth, 27/2/63.
405. Same as AM 404, July 1962.
406. Same as AM 27, 12/5/64.
407. Mouth of Norman River, Gulf of Carpentaria, Qld. Coll. D. F. McMichael and J. C. Yaldwyn, Dec. 1963. Intertidal beach boulders.
408. Sandgate, Moreton Bay, Qld. J. S. Hynd collection, 19/3/45.
409. Townsville, Qld. Trawled in 15–20 fms. Coll. T. Nielson, Nov. 1964.
410. Same as AM 43. 35–40 fms, Sta. 6.
411. Same as AM 302.
412. Same as AM 102.
413. Long Bay, N.S.W. A. R. McCulloch, 28/4/07.
415. Shark Bay, W.A. CSIRO Fisheries, 27/9/48. Trawled, from sponges.
416. Same as AM 43.
417. Same as AM 410.
418. Coral Reef, Myora, Stradbroke I., Moreton Bay, Qld. J. S. Hynd collection.
419. Cape Inscription, Dirk Hartog I., W.A. CSIRO Fisheries, 24/9/48. From sponge.
420. Bountiful I., Gulf of Carpentaria, Qld. Coll. J. C. Yaldwyn, 30/11/63. From intertidal rock platform.
421. Same as AM 355.
422. Long Reef, Collaroy, N.S.W. Coll. Miss B. Campbell, 19/3/61. Intertidal rock platform.
423. Same as AM 281, 12/10/65.
424. Seal Rocks, Port Curtis, Qld. J. S. Hynd collection, 28/8/46. Intertidal rock pool.
425. Murray I., Torres Str., Qld. Coll. M. Ward, Oct. 1928.
426. Southern Gulf of Carpentaria, Qld. CSIRO Prawn Survey. Coll. D. F. McMichael, Dec. 1963. From holes in massive sponge trawled in less than 14 fms.
427. Same as AM 41. 27/1/64.
428. Kenn Reef, Coral Sea, Qld. Coll. D. F. McMichael, 2/10/60.
429. Curtis Channel, off Bundaberg, Qld. Dredged 20 fms. 30/8/46.
430. Same as AM 27.
432. Heron I., Capricorn Group, Qld. Coll. Mrs F. Evans, Dec. 1962.
436. Same as AM 27.
437. Off Cape Moreton, Qld., trawled from S.S. *Cape Leeuwin.* 11 fms. J. S. Hynd collection, 19/12/46.
438. Same as AM 43.
439. Same as AM 103. Commensal on brown alcyonarian.
440. Same as AM 50.
441. Same as AM 41, 20/4/62.
442. Same as AM 41, 20/4/62.
443. Curtis Channel, off Bundaberg, Qld. 20 fms. 30/8/46.
444. Sweers I., Gulf of Carpentaria, Qld. CSIRO Prawn Survey. Trawled in less than 14 fms. Coll. D. F. McMichael and J. C. Yaldwyn, Dec. 1963.
445. Anchorage Spit, Manly, near Brisbane, Moreton Bay, Qld. J. S. Hynd collection, 27/7/46.
446. S. of Peel I., Moreton Bay, Qld. 3–6 fms. Coll. W. Stephenson, 17/7/61.
447. Dredged off Roebuck Bay, Broome, W.A. From crinoid.
448. Same as AM 79, 26/10/46.
449. Gantheaume Point, Broome, W.A. Coll. A. A. Livingstone, 8/8/29. Intertidal, on reef, under stones.
450. Dredged between two beacons at S. end of Peel I., 18 ft. Coll. W. Stephenson.
451. Outer Banks, Myora, Stradbroke I., Moreton Bay, Qld. J. S. Hynd collection, 28/7/46.
452. Long Reef, Collaroy, N.S.W. 5/9/67. Reef platform.
453. Heron I., Capricorn Group, Qld. Sept. 1960. From coral reef, commensal on comatulid.
454. Orpheus I., Townsville, Qld. 15–20 ft. Coll. J. Bloomfield, 27/2/69.
456. Curtis Channel, off Bundaberg, Qld. 20 fms. J. S. Hynd collection, 30/8/46.

AM 459. Barron River, Cairns, Qld. Coll. B. Campbell, Oct. 1963. Downstream from road bridge (salinity at low water c. 90/00) within network of interconnecting *Sesarma* crab burrows and chambers, 3 ft below surface of river bank at water table. Same loc. as AM 96.

AM E. 3147. 13 mi. SE. of Cape Capricorn, Keppel Bay, Qld. 13 fms. 27/10/10.*

[*All "E" numbers refer to collections made by the Fisheries Investigation Ship *Endeavour* between 1909–1914.]

AM E. 3159. 12 mi. NNE. of Bowen, Qld. 19–25 fms. 2/8/10.
3180. Off Point Inskip, Great Sandy Str., Qld. 10 fms. 27/7/10.
3190. 11–14 mi. NW. of Pine Peak, Percy Isles, Qld. 24–26 fms. 27/10/10.
4494. 18 mi. S. by W. of Lady Elliot I., Qld. 18 fms. 1913.
4495. Spencers Gulf, S.A. 16 fms. Before 1913.
4497. Same locality. 20 fms. 1913.
4499. Same locality. 16 fms. Before 1913.
4500. Cape Marsden, Kangaroo I., S.A. 1913.
5679. 10 mi. N. of Circular Head, Tasmania. Before 1914.
6274. 40 mi. W. of Kingstone, S.A.
6667. 20 mi. NNE. of Double I. Point, Qld. 30 fms. 29/6/10.

AM G. 614. Port Phillip, Victoria. Pres. J. B. Wilson, 1892.
1789. Houghton I., Howick Group, Qld. Pres. Dr De La Garde, 1898.
2190. *Thetis* Stn. 14, off Norah Head, N.S.W. 25–32 fms. 27/2/98.
3283. Green I., near Cairns, Qld. Coll. C. Hedley.
4101. Calloundra Beach, Qld. Pres. H. L. Kesteven, 1902.
4249. Launceston, Tasmania. Exchanged 1903.
5782. Mossman's Bay, Port Jackson, N.S.W., before 1907. Coll. Mrs F. E. Grant.
6139. Manly, near Sydney, N.S.W., before 1907. Coll. Bassett-Hull, Jr.

AM P. 836. Fraser I., Qld. Rec. 1908. Coll. Kirton.
858. Miller's Point, Port Jackson, N.S.W., before 1908. Coll. A. R. McCulloch.
1182–3. Lord Howe I., Tasman Sea. Rec. 1908. Coll. Mrs Nichols.
1418. Watson's Bay, Port Jackson, N.S.W. Rec. 1908.
1436. Port Jackson, N.S.W. 1892.
1441. Same as 1436, before 1908.
1452–3. Same as 1441.
1632–5. Upper reaches Sydney Harbour, N.S.W. June 1961. Coll. Miss I. Bennett in prawn trawl.
1649. Lord Howe I., *Thetis* Expedition, March–April 1898.
1695. Shell Beach, Balmoral, Port Jackson, N.S.W. 4/7/01. Coll. T. Whitelegge.
1966. Port Curtis, near Gatcombe Head, Qld. 6 fms. Pres. A. McCulloch, Jan. 1909.
2006–7. Rat I., Port Curtis, Qld. Pres. A. R. McCulloch, 1909.
2021–2. Ryde, Parramatta River, near Sydney, N.S.W. Pres. Fry and Kinghorn, 1909.

2055. Port Phillip, Victoria. Pres. A. R. McCulloch, 1909.
2149. Shark I., Port Jackson, N.S.W. Pres. A. R. McCulloch, 1909.
2152. Rose Bay, Port Jackson, N.S.W. Pres. A. R. McCulloch, 1909.
2218. Mud I., Moreton Bay, N.S.W. Pres. A. R. McCulloch, 1909.
2220. Lord Howe I., Tasman Sea. Pres. A. R. McCulloch, 1909.
2289. Dunk I., near Tully, Qld. Pres. I. J. Banfield, 1909.
2329. 10 mi. N. of Circular Head, Tasmania. Pres. Comm. Fish Bureau, 1909.
2344, 47, 49. South Australia. Exch. Baker, 1909.
2577–80. Masthead I., Qld. Rec. 1911. Coll. D. B. Fry.
2768. Albany District, W.A. Rec. 1911. Coll. A. Abjornsen.
3014. Western Port, Victoria. Pres. J. Gabriel, 1912.
2071–2. Maroubra, near Sydney, N.S.W. 1912. Coll. A. R. McCulloch.
3127. Albany Passage, Cape York, Qld. 1912. Coll. Hedley and McCulloch.
3544. 12 mi. SE. of Cape Capricorn, Keppel Bay, Qld. 29/7/10.
3566. Great Sandy Str., Qld. 27/7/10. Coll. *Endeavour* Exped.
3574. Pine Peak, SE. Percy I., Qld. 1/8/10. Coll. *Endeavour* Exped.
3581. No collection information.
3662. Near Fremantle, W.A. Exch. W.A. Museum, 1913.
3956. Portsea Pier, Port Phillip, Victoria. Pres. Chas. J. Gabriel, 1914.
4073. Narooma, south coast of N.S.W. Coll. C. Hedley, Feb. 1916.
4103. Eagle I., N. Qld. 23/7/16. Coll. C. Hedley and E. A. Briggs.

AM.P. 4229. Port Denison, Qld. July 1918. Coll. E. H. Rainford.

4288. Finches Bay, Cooktown, Qld. Sept. 1918. Coll. A. R. McCulloch.

4303. Outer edge, St. Crispin Reef, off Port Douglas, Qld. Sept. 1918. Coll. A. R. McCulloch.

4313. Hope I., near Qld. Coll. A. R. McCulloch, Sept. 1918.

4480. Port Arthur, Tasmania. Pres. E. Mawle 1919.

4497. Woolwich, Lane Cove River, Sydney, N.S.W. Coll. R. Kinghorn, 18/12/19.

4601–2. Lagoon, South West Rocks, Trial Bay, about 1/4 mi. from ocean beach, N.S.W. Coll. J. R. Kinghorn, before 1920.

4681. Port Hunter, Newcastle, N.S.W. Pres. D. G. Stead, 15/3/07.

4760. Straw Beach Quarantine, Port Jackson, N.S.W. Pres. D. G. Stead. Rec. 1920.

4761. Same as P. 4681.

4837–39. Kingscote, Kangaroo I., S.A. Coll. E. L. G. Troughton. Rec. 1920.

4863. Port Stephens, N.S.W. Jan. 1920. Dredged. Exch. E. A. Briggs, Sydney Univ.

4933. On coast at Coogee, near Sydney, N.S.W. Pres. F. A. McNeill. August 1920.

4950. Long Reef, Collaroy, N.S.W. Pres. Miss E. Helms, 6/3/12.

4996. Norfolk I., S. Pacific. Pres. R. M. and W. Laing, and J. C. Quintal by Prof. Chilton and A. Liddell. Rec. 1920.

5028–29. On coast at Coogee, near Sydney, N.S.W. Coll. McNeill and Livingstone, 1920. From rock pool.

5116. Rose Bay, Port Jackson, N.S.W. Pres. State Trawling Industry, 1921. From dredge.

5137. Trial Bay, N.S.W. Coll. A. Kinghorn, before 1921.

5215. Bowen Harbour, Qld. Coll. E. H. Rainford, before 1921.

5275–77. Lord Howe I., Tasman Sea. Pres. A. R. McCulloch, before 1921.

5305. Hole in Wall, on coast near Broken Bay, N.S.W. Coll. F. A. McNeill. Rec. 1921. From rock pool.

5314. Saddleback I., Qld. Pres. E. H. Rainford, before 1921.

5349. Off Norah Head, N.S.W. 23–38 fms. Coll. McNeill and Livingstone, June 1921.

5356. Brighton le Sands Beach, Botany Bay, N.S.W. Pres. A. Livingstone, 4/7/21. Washed up after storm.

5491. Wilson's Point, Port Jackson, N.S.W. Pres. P. Barkie. Rec. 1921. From pile.

5572–73. Holbourne I., N. Qld. Pres. E. H. Rainford, 1921.

5610. Port Denison, N. Qld. Pres. E. H. Rainford, 1921.

5710–11. Lord Howe I., Tasman Sea. Coll. A. R. McCulloch and E. L. G. Troughton, before 1922.

6102. Western Port, Victoria. Pres. C. J. Gabriel, May 1915.

6107. Double Cone I., Whitsunday Group, Qld. Pres. E. H. Rainford, 1923. From cavities in dead coral dredged from depth of 20 ft.

6308–9. Shell Harbour, N.S.W. Pres. G. McAndrew, 1923.

6350–53. Caloundra, Qld. Coll. A. A. Livingstone, 11/14/22.

6354–55. Point Cartwright, Qld. Coll. A. A. Livingstone, 2/8/22.

6449. Sailor's Bay, Middle Harbour, Port Jackson, N.S.W. Pres. W. Boardman, 1923.

6468. Clareville Beach, Pittwater, Broken Bay, N.S.W. Pres. G. P. Whitely, 1923.

6487–88. Dredged between Sow and Pigs Reef and Green Point, Port Jackson, N.S.W. Coll. H. O. Fletcher, 25/8/23.

6495. Bottle and Glass Rocks, Port Jackson, N.S.W. Coll. A. A. Livingstone, 28/7/23. Intertidal.

6514–15. Dredged between Sow and Pigs Reef and Shark I., Port Jackson, N.S.W. 5–7 fms. Coll. F. A. McNeill, 16/5/23.

6526–27. Fairybower, Manly, N.S.W. Coll. A. A. Livingstone, 20/10/22.

6565. Long Reef, Collaroy, N.S.W. Coll. F. A. McNeill, 6/11/22.

6605. Base Beach, Vanderlin I., Sir Edw. Pellew Group, Gulf of Carpentaria, Qld. Pres. W. E. J. Paradice, before 1923. From a clump of live coral hauled in by seine net on a beach.

6682. Shark I., Port Jackson, N.S.W. Coll. F. A. McNeill and A. A. Livingstone, Jan. 1922.

6710. Gunnamatta Bay, Port Hacking, N.S.W. Coll. F. A. McNeill, 6/10/22.

6786. Great Barrier Reef, Qld. Pres. W. E. J. Paradice, R.A.N., 1923.

6825. Rail Pier, Port Darwin, N.T. Coll. W. E. J. Paradice, 1923.

6861. Freshwater Beach near Manly, Sydney, N.S.W. 6–10 ft below low tide mark. Pres. A. F. Basset-Hull, 5/1/24.

6862–3. Lord Howe I., Tasman Sea. Pres. G. P. Whitley, 1924.

6910–14. On coast 2 mi. south of entrance of Tuggerah Lakes, N.S.W. Coll. A. A. Livingstone and H. Fletcher, 1924. From intertidal rock pools.

AM P. 7027. Bowen Harbour, Port Denison, Qld. Pres. E. H. Rainford, 1924. Dredged, hard sand and mud bottom, 15–20 ft.
7050. Alongside Bowen Jetty, Port Denison, Qld. Pres. E. H. Rainford, 1924. Hand netted in patch of weed, low tide in 3 ft of water.
7164–65. Shellharbour, N.S.W. Coll. F. A. McNeill, 1924. Intertidal, under stones.
7187. Long Reef, Collaroy, N.S.W. Pres. W. Boardman, 5/4/24. Intertidal under stones on sandy beach.
7221. E. of Ulladulla, N.S.W. 35° 20′ S., 150° 47′ E. 74 fms. Pres. C. W. Mulvey, May 1924. Off conglomerate boulder taken by trawler *Goonambee.*
7224. 16–18 mi. NE. of South Head, Port Jackson, N.S.W. 75–80 fms. Pres. J. Wright, 1924. From Conglomerate boulder taken by trawler *Goonambee.*
7234. Off Towra Point, Botany Bay, N.S.W. Pres. J. H. Wright, April 1924. From kelp holdfast.
7240. Shellharbour, N.S.W. Intertidal. Pres. G. McAndrew, 1924.
7309. Armit I., Whitsunday Group, Qld. Pres. E. H. Rainford, 1924. From coral.
7377, 79. 12–22 mi. NE. from Cape Green, N.S.W. 36–46 fms. Coll. A. A. Livingstone and H. O. Fletcher, June 1924
7421–22. Masthead I., Capricorn Group, Qld. Coll. A. R. McCulloch, Nov.–Dec. 1913.
7440, 43, 54. Murray I., Qld. Coll. C. Hedley and A. R. McCulloch, Aug.–Oct. 1907.
7463, 76. Long Reef, Collaroy, N.S.W. Intertidal. Exch. M. Ward, 1924. In holes amongst sand and pebbles, under boulders.
7520–24. Queensland. Coll. A. R. McCulloch, 1924.
7557. Cairns Reef, off Cooktown, Qld. Coll. A. R. McCulloch, 1924.
7711. No collecting information.
7902–3, 7952. Shell Harbour, N.S.W. Pres. G. McAndrew, 1925.
7981–2. Reef, High I., Frankland Group, Qld. Pres. W. E. J. Paradice, 1924.
8009. North Barnard I., Qld. Pres. W. E. J. Paradice, 1924.
8026–28. Frankland Group, Qld. Pres. W. E. J. Paradice, 1924.
8043. Low (Woody) I., off Port Douglas, Qld. Pres. W. E. J. Paradice, 1924.
8230. 8 mi. S. of Green Cape, N.S.W. 30 fms. Coll. M. Boardman, on trawler S.S. *Bar-ea-mul.* 20/7/25.
8255. Gunnamatta Bay, Port Hacking, N.S.W. Coll. C. Anderson and F. A. McNeill, 1925.
8266. Port Phillip, Victoria. Pres. M. Ward, 1925. Dredged.
8416. Gunnamatta Bay, Port Hacking, N.S.W. Coll. Museum Party, 3–5 Oct. 1925. From tidal flats.
8437–38. Shellharbour, N.S.W. Pres. G. McAndrew, 1925. Intertidal.
8550. Sandy Point, Broken Bay, Hawkesbury River, N.S.W. Pres. M. Ward, 1926.
8565–67, 77. Reef, North West I., Capricorn Group, Qld. Pres. G. P. Whitley, Dec. 1925.
8695. Bottle and Glass Rocks, Port Jackson, N.S.W. Pres. M. Ward, 1926.
8701–02. Sea Port, Port Phillip, Victoria. Pres. M. Ward, 1926.
8706. Long Reef, Collaroy, N.S.W. Pres. M. Ward, 1926.
8786. Sea Port, Port Phillip, Victoria. Pres. M. Ward, 1926.
8787. Hook Reef, E. of Bowen, Qld. Pres. Surg. Lieut. L. Lockwood, 1927.
8793. Gt. Barrier Reef, near Bowen, Qld. Pres. Surg. Lieut. L. Lockwood, 1927.
8794. Knight Reef, Clarence Str., N.T. Pres. Surg. Lieut. L. G. Courtney, 1927.
8866. Shellharbour, N.S.W. Pres. G. McAndrew, 1927.
8963. Botany Bay, N.S.W. 15 ft. Coll. F. A. McNeill, 6/10/27.
8970. Walsh Bay, No. 3 jetty, Port Jackson, N.S.W. Coll. F. A. McNeill, 11/10/27. On piece of test timber.
9064. Long Reef, Collaroy, N.S.W. Intertidal. Pres. M. Ward, 21/4/28.
9068. Woodford Bay, Lane Cove River, Sydney, N.S.W. Pres. G. R. Kinghorn. In shallows on tidal flats.
9072. Long Reef, Collaroy, N.S.W. Pres. M. Ward, 21/4/28.
9076–77. Shore, Woolloomooloo Bay, Port Jackson, N.S.W. Intertidal. Pres. M. Ward, 7/3/28.
9337. Shell Harbour, N.S.W. Pres. G. McAndrew, 1929.
9422–23. Port Willunga, S.A. Pres. H. M. Hale, 1930.
9431. Long Reef, Collaroy, N.S.W. Coll. F. A. McNeill, 1930.
9448. WSW. from Gabo I., Victoria. 70 fms. Pres. Capt. K. Moller, 1930.
9481. Port Darwin, N.T. Pres. L. B. Wilson, 1930.
9670. Port Curtis, Qld. Pres. C. Bedsor, 1930.
10038. North West I., Capricorn Group, Qld. 9 fms. Coll. A. A. Livingstone and W. Boardman, Dec. 1930–Jan. 1931.

AM P. 10092. Sow and Pigs Shoal, Port Jackson, N.S.W. Low water mark. Pres. Capt. L. Comtesse, 1931.

10114. Sow and Pigs Shoal, Port Jackson, N.S.W. Coll. F. A. McNeill, 14/2/30.

10125. Sandgate, Brisbane River, Qld. Pres. C. J. Watson, 1931.

10201. Broome, W.A. Pres. H. L. Clark and E. W. Bennett, June 1932.

10311–12, 22. Lord Howe I., Tasman Sea. Coll. A. A. Livingstone, 1933. From reef.

10364. North West I., Capricorn Group, Qld. Coll. F. A. McNeill, 1933.

10401. Hayman I., Whitsunday Group, Qld. Pres. F. A. McNeill, Jan. 1933.

10533–34. Hayman I., Whitsunday Group, Qld. 5 fms. Pres. F. A. McNeill, 1934.

10770. Brunswick Heads, N.S.W. Coll. E. Troughton and A. Musgrave, Aug. 1936.

10784. Middleton Reef, N. of Lord Howe I., S. Pacific Ocean. Coll. G. P. Whitley, April 1936.

10837. Moonta, S. Australia. Coll. K. Reed, 1937.

10979–81. Reef, Shelly Beach, near Yamba, N. of Clarence River, N.S.W. Coll. A. A. Cameron, May 1938.

11187. Shelly Beach, Yamba, N.S.W. Pres. A. A. Cameron, 18/10/39.

11271–72. Angourie, near Yamba, N.S.W. Pres. A. A. Cameron, 22/2/40.

11296. Near mouth of Clarence River, Yamba, N.S.W. Pres. A. A. Cameron.

11340. Woody Head, near Yamba, N.S.W. Pres. A. A. Cameron.

11359. Angourie, near Yamba, N.S.W. Coll. Joyce Allan and A. A. Cameron.

11400–01. Claremont Islands, Princess Charlotte Bay, N. Qld.

11408. Port Molle, Whitsunday Passage, Qld. Coll. W. A. Haswell, while with H.M.S. *Alert.* On reefs.

11416. Botany Bay, N.S.W. A. H. S. Lucas and Museum party.

11440. Between Peel I. and Cleveland, Moreton Bay, Qld.

11451. Gunnamatta, Port Hacking, N.S.W.

11730. Gunnamatta Bay, Port Hacking, N.S.W. Coll. E. Pope, March 1947. Hand-netted in weed on tidal flat.

11731–33. Long Reef, Collaroy, N.S.W. Coll. E. Pope, March 1947. Intertidal, under stones.

11734. Near Watson's Bay, Port Jackson, N.S.W. Coll. E. Pope, 1946. From growths on boom pile defence drawn after war.

11759. Ulladulla, N.S.W. Coll. M. E. Coles, 1947. Seine netted by small fishing trawler.

11763. Kennedy Sound, Cumberland Group, Qld. Pres. G. P. Whitley, 1935. Dredged.

11779. Lindeman I., Cumberland Group, Qld. Pres. G. P. Whitley, 1935.

11877. Newcastle district, N.S.W. Coll. C. Moreley. In batch of prawns.

11882. Brampton I., near Mackay, Qld. Pres. Miss B. Dew.

12127. Long Reef, Collaroy, N.S.W. Pres. P. Colman, Jan. 1952. From coastal reef at low-tide in encrusting sponge.

12426–27. Cottesloe Beach, W.A. Aug. 1954.

12920. Heron I., Capricorn Group, Qld. Pres. Miss B. Dew, Jan. 1955. From coral reef flat.

12927, 36. Port Jackson, N.S.W. Coll. A. A. Racek, Jan. 1953.

12928. Off Port Jackson, N.S.W. 10 ft. Coll. A. A. Racek, Dec. 1953.

12952. Stockton Bight, N.S.W. Pres. A. A. Racek, Jan. 1955. From trawl.

13487. Woody Head, Iluka, mouth of Clarence River, N.S.W. Coll. A. A. Cameron, 3/9/60.

13509. Backy Point, near Whyalla, S.A. Coll. B. Flounders, Feb. 1961. Intertidal.

13546. Watson's Bay, Port Jackson, N.S.W.

13547, 49. Mast Head I., Capricorn Group, Qld. F. E. Grant. From coral reef flat.

13548. Shoreham, Victoria. 31/3/02. Under stones, low tide.

13549. Masthead I., Capricorn Group, Qld. Coral reef flat. Coll. F. E. Grant.

13550. Port Curtis, Qld. 5–11 fms. Dredged.

13551. Off North Head, Flinders, Victoria. 30/13/00. Dredged.

13553, 55, 57. Lord Howe I., Tasman Sea.

13554. Murray I., Torres Str., Qld. 17 fms. Coll. A. R. McCulloch, 1907.

13556, 59. Between Ball's Head and Goat I., Port Jackson, N.S.W. Coll. J. Brazier. Dredged.

13558. Port Jackson, N.S.W.

13560. Watson's Bay, Port Jackson, N.S.W.

13561. Mapoon, Gulf of Carpentaria, Qld. Coll. Park. June 1907.

13562. Nelson's Bay, Port Stephens, N.S.W.

13563. Port Jackson, N.S.W.

13564. Port Curtis, Qld. Dredged 4 fms.

AM P. 13565. Between Ball's Head and Goat I., Port Jackson, N.S.W. Dredged.
13567. Farm Cove, Port Jackson, N.S.W.
13568. Cairns Reef, Cooktown, Qld. Coll. A. R. McCulloch.
13569. Yeppoon, near Townsville, Qld.
13570. Port Jackson, N.S.W.
13571. Lord Howe I., Tasman Sea.
13572–73. Cairns Reef, Cooktown, Qld. Coll. A. R. McCulloch.
13574. Mast Head I., Capricorn Group, Qld. Coll. F. E. Grant. From coral reef flat.
13575–76. Port Jackson, N.S.W.
13577. Botany Bay, N.S.W.
13578. Nelson's Bay, Port Stephens, N.S.W.
13579. Victoria. Coll. F. E. Grant.
13580. Port Jackson, N.S.W.
13581. Port Stephens, N.S.W.
13582. Port Phillip, Victoria. Coll. J. Gabriel, March 1907.
13583. Encounter Bay, S.A. 10–15 fms.
13584. Cairns Reef, off Cooktown, Qld.
13585. Nelson's Bay, Port Stephens, N.S.W.
14630. Botany Bay, N.S.W. Como side of Georges River bridge. 15 ft. Coll. D. Lelliot, 4/6/62.
14631. Upper reaches of Sydney Harbour, N.S.W. Coll. Miss I. Bennett. Caught in prawn trawl.
14639. Old Settlement Beach, Lord Howe I., Tasman Sea. Coll. J. Booth, 24/9/62.
14958. Bowen, Qld.
14959. Victoria. Pres. F. E. Grant.
14960. Cairns Reef, Cooktown, Qld. Coll. A. R. McCulloch.
17999–17800. Same as AM 15.
18001. Same as AM 415.
18002–18003. Same as BAU 32.
18004. Same as UQ 34.
18005. Same as AM 338.
18006. Same as AM 283.
18007. Same as AM 390.
18008. Same as AM 215.

PERSONAL COLLECTIONS MADE BY A. H. AND D. M. BANNER

The bulk of these collections will be deposited at the Bernice Pauahi Bishop Museum, Honolulu, but some duplicates will be deposited in the Australian Museum, Sydney.

BAU 1. Point Peron, W.A. 3–6 ft. 13/12/67. Off Physical Fitness Camp, N. side of point within surf line, from coralline algae. [Only the first of each day's collections are dated.]
2. Point Peron, W.A. 2–4 ft. Off S. side of point, in loose pieces of beach sandstone with holes, within the surf line.
3. Lancelin I., W.A. 14/12/67. From dead coral heads almost at surf line, 1/4 mi. from shore, on outer reef.
4. Same locality. 4–8 ft. From reef flat on NE. side. From scattered calcium carbonate boulders beyond a narrow terrace.
5. Same locality. 2–10 ft. From potholes on inner side of "barrier reef" front. From live *Pocillopora* sp., a few dead coral heads and coralline algae masses.
5a. Jurien Bay, Perth, W.A. 3–4 m. 16/12/67. Trawled at night over weed.
5b. City of Gold, Qld. 26/12/67. Mangrove swamp, intertidal.
6. Yeppoon, Qld. 29/12/67. Intertidal, near low tide zone, under rocks.
7. Same locality. Similar to BAU 6 but isolated rock patch and more exposed to wave action.
8. Yule Beach, near Port Douglas, Qld. 2/1/68. Intertidal.
9. Pebble Beach, N. Qld. 3/1/68. Intertidal, under rocks, sandy rocky beach.
10. Green I. (off Cairns), Qld. 4/1/68. On reef flat extension, not over one foot below low-low water. From dead and overgrown coral heads, mostly *Acropora* sp.
11. NE. side of Green I., Qld. 2–6 ft below low-low water. 4/1/68. Patch reef, dead and overgrown *Acropora* sp.

BAU 12. Same locality. 5/1/68. Intertidal, under rocks.

13. Same locality. Intertidal, reef flat. From dead base of small head of *Pocillopora* sp.

14. Arlington Reef (about 1.5 miles off Green I.), Qld. 6–8 ft. 6/1/68. Vigorous reef.

15. Same locality. 6–8 ft deep. Near reef edge.

16. Same locality. From middle reef exposed at low water.

17. Same locality. 8 ft deep. From massive *Porites* sp.

18. Same locality. Near reef edge.

19. Same as BAU 16. About 2 mi. E. of Home Reef. From under coralline algae.

20. Same locality. Reef flat, near exposure at low-low water. From various dead and overgrown heads.

21. Same locality, outer edge of reef. 2–8 ft deep.

23. Home Reef, Green I., Qld. 7/1/68. From reef flat at zero tide level, from heads of *Porites* sp., mostly dead.

24. Green I., Qld. SE. tip. Slightly below low-low water. Area with 10 ft broad pot holes with sand bottoms and much dead coral and live soft corals.

25. Thursday I., Torres Str., Qld. 0–6 ft deep. 9/1/68. From reefs E. of village and "channel" between Thursday and Horn I. Collected at edge of eel grass from dead coral heads and sponges, in general bottom of very fine lime sand.

26. Thursday I., Qld. About low-low tide level. 10/1/68. In front of village at low tide. Under rocks, sandy to muddy bottom.

27. Hammond and Waiwea I., Torres Str., Qld. Three reefs, from 0–10 ft depths. Reef tops of fine sand, nearer edge mostly dead madreporarians and live alcyonarians. Currents strong.

28. Thursday I., Qld. 2–10 ft deep. NE. side and N. end of Thursday I., Qld. Collected from various heads of dead coral.

29. Rudder Reef, off Port Douglas, Qld. 14/1/68. Exposed at low water. From outer reef flat, 200 yds from reef edge. Almost no sand, but composed of broken pieces carried inward by storms. Reef subject to heavy surf and SE. winds.

30. Same locality. Exposed at low-low water, reef flat at edge, subject to heavy surf.

31. Opal reef, off Port Douglas, Qld. 15/1/68. 5–10 ft deep. From lee side, sand bottom with coral patches, all pried from consolidated heads.

32. Same locality. 0–5 ft deep. From frontal edge where seas normally break. From consolidated heads broken loose from reef, mostly heads covered with coralline algae.

33. Chinaman's Reef, midway between Rudder and Opal Reef, off Port Douglas, Qld. From 0–10 ft deep. Frontal edge depth and general condition same as BAU 32, but not so much coral, and coral not as rich in alpheids.

34. Rowes Bay, Townsville, Qld. 18/1/68. Intertidal, under rocks. Substrate granite sand to slightly muddy sand.

35. Molle I., Whitsunday Group, Qld. 20/1/68. From causeway between South and Middle Molle. From beach near mid-tide level, under large rock in sandy substrate, area apparently subject to strong currents at high tide.

36. Hayman I., Whitsunday Group, Qld. Under rocks at near low water.

37. Bali Hai I., off Hayman I., Whitsunday Group, Qld. 2–6 ft deep. 21/1/68. At growing edge of reef. Coral growth not vigorous.

38. N. side, Bali Hai reef, Qld. Reef flat at —2 ft. Substrate of sand, littered with both granite and coral.

39. Off Bali Hai I., towards Hayman I., Qld. From 2 dead overgrown coral heads. Bottom of sand with much sea weed; only occasional loose pieces of dead coral.

40. Reef edge, E. of Bali Hai, towards Hook I., Qld. 2–6 ft deep. Much soft coral, some growing corals.

41. Langford I., near Hayman I., Qld. 22/1/68. About medium low tide under terrigenous rocks and under beach rock, both lying embedded in coarse to fine sand, apparently in areas of fresh water seepage.

42. Hook I., in cover SE. of Hayman I., Qld. 2–6 ft deep. In dead coral, mostly *Porites* sp., from reef in middle of cave.

43. Same locality, near small point to W. of BAU 42. 2–6 ft deep. Coral more sparse, but currents stronger than BAU 42. Mostly from overgrown heads of *Acropora* sp. and one massive head, genus unknown.

44. Hayman I., Qld. 2–6 ft, on W. end of northern reef. 23/1/68. Bottom mostly consolidated dead coral with some coral rubble.

45. 10 mi. N. of St Lawrence, Qld. 25/1/68. Under rocks at mid-tide level. Quite a bit of organic matter mixed with substrate.

46. Heron I., Capricorn Group, Qld. 28/1/68. Shore collecting on a +2.8 tide. Under pieces of broken beach sandstone, low in intertidal where sand substrate was wet from beach run off. Water salty to brackish.

BAU 47. Same locality. From low-low tide level to about —5 ft. 29/1/68. At outer edge of coralline ridge on reef directly S. of Heron I., Qld. Pieces pried off consolidated ridge surface, some overgrown with coralline algae, some living coral.

48. Same locality. Depths —5 to —25 ft. From seaward face of reef. Face mostly consolidated living and dead corals cemented by coralline algae. Specimens mostly from small fragments broken from consolidated coral, many from associated sponges.

49. Same locality. About 0 tide level. 30/1/68. On coralline ridge directly N. of island. Ridge composed of solid plates, cemented together with a thick layer of coralline algae with almost no holes for shrimp.

50. Same locality. 30/1/68. On SE. side of island, at edge of tidal "stream" next to island on reef flat. At low tide this is 50 ft wide and 1 ft deep and carries the water from the reef flat at high speed. Collection from mostly dead, coarsely branched heads and between layers of encrusting coral.

51. Same locality. Same as BAU 46. Shore collecting under stones, tide slightly lower than in BAU 46.

52. Same locality. From reef flat —2 to —3 ft below low-low water. 31/1/68. About 1.5 miles due east of island. Isolated coral patches on sand substrate; coral mostly loose. Heads in patches arising several feet above sand flats.

53. Same locality, further east than BAU 52, at edge of "lagoon". Conditions similar to BAU 52 except sand bottom several feet deeper and living coral reaching 5 ft above level of sand. Specimens mostly from dead heads of *Pocillopora* sp. A massive head of coralline algae yielded almost nothing.

54. Same locality. Same as BAU 50, but middle of reef flat at —1 ft depth. Sand bottom with numerous loosely consolidated coral masses of many species. Dominant coral a heavily branched *Porites* sp.

55. Same locality, in eastern lagoon (see BAU 53). 10 ft. 1/2/68. Sand bottom with large coral mounds reaching to near 0.0 tide level. Specimens collected from mostly dead coral, some pried off top or side of massive mounds, some lying free on bottom near mounds.

56. Same locality, immediately shoreward of ridge at BAU 47, through boulder zone into outer growing reef area. Tops of coral and lithothamnian ridge exposed at low-low tide, moderate wave action. Specimens rare.

57. Same locality. 2–15 ft deep. 2/2/68. Reef front S. of eastern end of island, below and beyond consolidated ridge. Corals mostly living and firmly fixed. Specimens from dead and dying coral pried loose from reef front, specimens not plentiful.

58. Same locality. Area to west of BAU 56, similar except ridge with more coral and less coralline algae; zone behind ridge filled with coral detritus, with almost nothing alive. Specimens came from behind dead zone where sand packets were 30–40 ft across, and 2 ft below reef surface with vigorously growing coral on edges.

59. Stradbroke I., near Dunwich, Qld. 7/2/68. Under rocks on sandy-muddy substrate. At edge of neap tide.

60. Same locality. In muddy sand covered with short eel grass at edge of neap tide. No associated rocks.

61. Same locality. Under clusters of mussels at edge of neap tide, sandy substrate.

62. Shelley Beach, Port Macquarie, Qld., at 2.6 tide. 10/2/68. Under rocks on ocean beach. Specimens found only in areas where medium sized rocks, up to 18 inches across rested in a stable configuration on a substrate of small rocks and sand. Evidently this arrangement could withstand the onslaught of waves.

72. Dudley Point, Darwin, N.T. 18/2/68. Collection made at +2.7 tidal level. Under rocks on shore. Much of shore muddy and without alpheids, but specimens were found under rocks on clean sand, particularly if there was a trickle of beach water.

73. Point at eastern edge of Night Cliff, Darwin, N.T. 19/2/68. About —3 to —4 ft tide. Area unprotected from northerly winds and waves. Sand well washed without any silt and the rocks are usually deeply embedded. No specimens were found under fully exposed rocks lying in loose sand, but occurred under rocks bedded in sand at edge of tide pools; this latter area semi-protected from onslaught of waves by numerous much larger rocks.

74. Same locality. Approximately one ft higher in tidal zone than BAU 73. In area of smooth ochre clay substrate with small fissures through which water from beach "weep" flowed. Specimens under fine rocks (up to 2–3 inches across) wedged in fissures.

75. Darwin Harbour, N.T. 20/2/68. S. of piers at edge of mangrove area. Substrate soft mud with gravel and small rocks embedded and interlaced with mangrove roots. Alpheids found in shallow burrows in more gravely areas, relatively high in tide zone.

COLLECTIONS LOANED PERSONALLY BY C. R. SMALLEY*

*Present address, University of Western Australia, Perth, Western Australia. Mr Smalley also collected many of the specimens under the "UQ" designation. We are using his designation from his field work and prefacing them with CS.

CS 1a–1i, 2a–2c (specimen number). Cockburn Sd. near Perth, W.A. 10–11 fms. Coll. C. R. Smalley, 9/7/70. Trawled by the *Flinders*. From sponges.
1j–1k. Near Perth, W.A. 1970–71. From sponges.
1–10, 13–21, 33–36, 39 (batch number). Collection data same as for CS 1a–1i.
11, 12, 22–24, 38, 39. Collection data same as CS 1a–1i. 2–3/7/70.
25–28. Exmouth Gulf, W.A. Coll. C. R. Smalley, 22–23/10/70. Trawled. From sponges.
29, 30. Exmouth Gulf, W.A. Coll. T. White. Trawled. From crinoid.
31, 32, 40. Collection data same as CS 25. 24/10/70. From crinoid.
41–43. Bay of Rest, Exmouth Gulf, W.A. Coll. T. White, Aug. 1970. In mud of tidal pools.
44. Fremantle, Swan River, W.A. Coll. J. Kowarski, 7/3/71.
45. Collection data same as CS 44, 13/12/71.
46. Freshwater Bay, Swan River, W.A. Coll. C. R. Smalley, 4/6/70. In loose rock, muddy sand.
47. Same collection data as CS 46, 22/9/70.
48. Australind, Leschenault Inlet, W.A. Coll. C. R. Smalley, 3/5/70.
49. Mandurah, Pell Inlet, W.A. Coll. C. R. Smalley, 25/4/71.
50, 51. Exmouth Gulf, W.A. Coll. C. R. Smalley, 22–25/10/70. Trawled.
IIA3. Moreton Bay, South West Rocks, Peel I., Qld. Coll. S. Cook, Sept. 1970.
IIC2. Same as CS IIA3.
IIIB1. Same as CS IIA3.
IIIB2. Same as CS IIA3, March 1970.
IIID1. Same as CS IIA3.
IIIE2. Same as IIA3, June 1970.

COLLECTIONS MADE BY MR JOHN BOASE OF FANNIE BAY, DARWIN, N.T.

These specimens will be deposited in The Australian Museum.

JB 1. From mud flats in front of Fannie Bay Hotel, Darwin, N.T. 30/9/68.
2. Darwin, N.T. 3–35 ft. 30/9/68. Beside the main wharf, from crinoids.
3. Dudley Reef, in front of Fannie Bay Hotel, Darwin, N.T. 30/9/68. Commensal with crinoids.
4. Same as JB 3.
5. East Point, Darwin, N.T. 9/10/68. Commensal with crinoids.

COLLECTIONS FROM JAMES COOK UNIVERSITY OF NORTH QUEENSLAND, TOWNSVILLE

This collection, loaned by the University, was without catalogue designations, so we have assigned numbers prefaced with "JC". They will be catalogued upon their return to the University.

JC 1. Geoffrey Bay, Magnetic I., Qld. 17/12/62.
2. 10 mile beach via Bloomsbury, Qld. Coll. Zoology Dept, 22/5/66. On sandy beach.
3. Lodestone, off Townsville, Qld. Coll. Zoology Dept, 15/8/62. In coral reef.
4. Townsville breakwater, Qld. Coll. Blackman, 16/7/66. At low tide under rocks.
5. Kissing Point, Qld. 14/4/61. Pools at low water.
6. Far Beach, Mackay, Qld. Coll. Zoology Dept, 4/5/66. Sand beach.
7. Magnetic I., Qld. 3/4/66.
8. Arcadia Bay, Qld. Coll. M. S. Hopkins, May 1966. Under rocks.
9. Kissing Point, Qld. 3/4/66.
10. Magnetic I., Qld.
11. Bingil Bay via El Arish. 18/5/64. Under rocks, low water.
12. Cardwell, Qld. Coll. Zoology Dept, 23/6/63. Sandy beach.
13. Geoffrey Bay, Magnetic I., Qld. Coll. J. A. Johnson, 4/4/64. Under rocks.
14. Wilson's Beach near Proserpine, Qld. Coll. Zoology Dept, 17/5/66. Sandy-mud beach.
15. Lodestone Reef off Townsville, Qld. Coll. Zoology Dept, 15/8/62. From coral reef.

JC 16. Mackay, Qld. Coll. Zoology Dept, 21/5/64. Under piece of coral on sandy beach.
17. Ross River, Qld. Coll. C. Fell, 28/9/66. In burrow.
18. Geoffrey Bay, Magnetic I., Qld. Coll. RK and JB, 14/5/61.
19. Magnetic I., Qld. Coll. M. Scott, 5/8/66. From reef.
20. No collection information.
21. Kissing Point, Townsville, Qld. Coll. K. McCable, March 1968. In small intertidal pool.
22. No collection information.
23. Geoffrey Bay, Magnetic I., Qld. Coll. E. Gregson, 1/8/68. From coral.
24. Taylor Reef, E. Proserpine, Qld. Coll. A. Hansen, 14/4/68. From coral reef.
25. Kissing Point, Townsville, Qld. Coll. J. Tweddell, 9/6/68. From under rocks.
26. Alva Beach, Ayr, Qld. Coll. W. A. Green, 9/2/66. In mud bank.
27. Rowes Bay, Townsville, Qld. Coll. J. Tweddell, 24/5/68. Under rocks.
28. Beach near breakwater, Townsville, Qld. Coll. L. Ward, 12/6/68. Commensal with giant anemone.
29. Cape Pallarenda, Townsville, Qld. Coll. B. Dickson, 14/5/68. From sandy beach.
30. Rowes Bay, Townsville, Qld. Coll. M. Scott, 7/5/68.
31. Shelley Beach, Townsville, Qld. Coll. C. Patterson, 10/7/68.
32. Townsville, Qld. 15/8/70. From a large sponge dredged N. of Magnetic I.
33. Rowes Bay, Townsville, Qld. Coll. W. R. Dowd, 4/3/68. Under small rocks.

COLLECTIONS FROM MACLEAY MUSEUM, UNIVERSITY OF SYDNEY

The collections from Macleay Museum were on loan to the Australian Museum, thus they were originally labelled consecutively with our numbers of the Australian Museum series, (AM)

MM 72. Port Darwin, N.T.
86. Cape Grenville, Qld. 20 fms.
111. Percy I., Qld.
161. Tasmania.
166. Port Darwin, N.T.
176. Princess Charlotte Bay, Qld.
178. No collection information.
181. Sue Ilset, Torres Str., Qld.
204. Tasmania.
263. Endeavour River, Cooktown, Qld.
355. Same as MM 263.
414. Darnley I., Great Northeast Channel, Qld.
421. Same as MM 263.
434. Sue Ilset, Torres Str., Qld.

COLLECTIONS FROM THE QUEENSLAND MUSEUM, BRISBANE

The "W" series is the Museum's catalogue designation; we have prefaced it with "QM".

QM W 835. Bird I., Moreton Bay, Qld. Coll. Univ. Qld. Sci. Students' Assoc.
838. Goat I., Moreton Bay, Qld. Coll. Univ. Qld. Sci. Students Assoc.
999. Heron I., Capricorn Group, Qld. Coll. T. C. Marshall, 12/9/39.
1000. Same as W 999.
1052. Green I., Moreton Bay, Qld. 23/1/40.
1053. Same as W 1052.
1055. Same as W 1052. Alcyonarian zone in Keratose sponge.
1193. Moreton Bay, Qld. Coll. V. F. Collin, 15/1/41.
1224. Myora mud flats, Moreton Bay, Qld. Coll. Univ. Qld. Sci. Students Assoc., 4/6/41.
1265. Townsville, Qld. Coll. G. Coats, 23/6/41.
1296. Angourie, N.S.W. 9/7/41.
1417. Mud I., Moreton Bay, Qld. 15/1/41. Coll. U. F. Collin.
1467. Mud I., Moreton Bay, Qld.
2165. Coll. G. Coats, 23/5/41.
2234. Amity, Moreton Bay, Qld. Coll. J. E. Young, Sept. 1924.
2235. Cardwell, Qld. Jan. 1889.
2236. Darnley I., Qld. Coll. Dr Tosh.
2237. Sandgate, Qld. Coll. C. J. Wild, 3/4/07.

QM W 2238. Moreton Bay, Qld. Coll. D. Connor.

2239. South Port, SE. Queensland.

2240. Sandgate, Qld. Coll. T. C. Marshall and G. P. Whitley, 25/10/28.

2242. Dunwich, Qld. –/4/62. Mid shore *Zostera.*

2243. Victoria Point, Moreton Bay, Qld. 17/2/62. F. C. Vohra's Sta. 3. *Zostera.*

2244. Moreton Bay, Qld. Coll. F. C. Vohra, 1962.

2245. Victoria Point, Moreton Bay, Qld. 13/6/62.

2246. Moreton Bay, Qld. Coll. F. C. Vohra, 25/7/62.

2247. Southport, SE. Qld. Coll. R. Puhlman, 1920.

2248. Princess Charlotte Bay, Qld. Coll. Capt. T. Kerr.

2249. Bribie I., SE. Qld.

2381. Trawled off C. Moreton, SE. Qld. Coll. B. Harris, April 1965.

2391. Norman River, N. Qld. Coll. Dept Harbours & Marine, 7/6/65. From prawn trawl.

COLLECTIONS FROM THE QUEEN VICTORIA MUSEUM AND ART GALLERY, LAUNCESTON

The numbers are of the Museum's catalogue; the "QV" is our designation.

QV 1971–10–2, –3, –4, –5, –6, –7, –8, –10, –11, –12, –14. Collected at Green's Beach on the western side of mouth of Tamar River, N. Tasmania, from 1965–68.

1971–10–9. Collected at Kelso, 3 mi. S. of Green's Beach, Tasmania, 8/1/67.

COLLECTIONS MADE BY R. U. GOODING, BARBADOS, W.I.

This collection by Dr Gooding was entirely from Diadematid Sea Urchins; we have prefaced his collection numbers with "RG". The collection will be returned to him.

RG 536. Radar Reef, Rottnest I., W.A. 1 m. Coll. R. Mahon, A. Baynes, R. Gooding, 12/5/69. Among spines on ventral side of *Centrostephanus tenuispinus* collected under ledges in rock pools.

538. The Blowholes, near Quobba Point, N. W.A. 1–2 m. 21/6/69. From chloretone washings of *Diadema setosum* collected under coral heads and rocks in the deeper pools.

540. Point Moore, Geraldton, W.A. 3 m. 7/6/69. From *Centrostephanus tenuispinus* collected in niches and caves in coral rock on reef.

541. Off Glacier Point, near Cronulla, near Sydney, N.S.W. 4–5 m. Coll. C. Lawler and other Underwater Research group members and R. Gooding, 28/6/69. From *Centrostephanus rodgersi* collected between rock ridges on reef.

542. Bare I., near N. head of Botany Bay, N.S.W. 3–4 m. Coll. R. Gooding and Underwater Research Group members, 29/6/69.

547a. On reef between light-beacon and Clark I., NE. Qld. ⅓ m. July 1969. Coll. from *Echinometra* in rock pool.

551. Waterwich Reef, NE. Qld. 1 m. 25/7/69. From *Echinothrix diadema* collected in hollow at base of coral head.

620a. Off Signal Point, Lord Howe I., N.S.W. 0.5–1.5 m. 6/2/70. From *Centrostephanus rodgersi* in lagoon under rocks and coral.

620c. Same as 620a. From *Tripneustes gratilla.*

620d. Same as 620a. From *Heliocidaris tuberculata.*

620(2)d. Same as 620d.

621a. Erscott's Pass, W. side of Lord Howe I. 1 1/2 m. 7/2/70. From *Centrostephanus rodgersi* collected in hollows on rocks and coral.

622a. Ned's Beach, NE. end of Lord Howe I. ½–1 m. 8/2/70. From *Centrostephanus rodgersi* collected in hollows and crevices of rocks and coral.

623a. Norfolk I. From lagoon side of reef at E. end of Sydney Bay near entrance to Emily Bay. 1–2 m. 15/2/70. From *Centrostephanus rodgersi* collected from spaces under rocks and coral.

623b. Same as 623a. 1 1/2 m. From *Diadema savignyi.*

623(3)c. Norfolk I., off mouth of Emily Bay, E. side. 1–3 m. 26/2/70. From *Tripneustes gratilla.*

623 1/2. Norfolk I., rocks on S. side of Anson Bay. 1–1.5 m. 22/2/70. From chloretone washings of *Heliocidaris tuberculata.*

624. Norfolk I., "Crystal Pool" on W. side of Point Ross. 1–3 m. Coll. R. Gooding and S. Blaxland, 24/2/71. From *Centrostephanus rodgersi* found in holes and rocky sides of pool.

COLLECTIONS FROM THE SOUTH AUSTRALIAN MUSEUM, ADELAIDE

The "SM" is our preface; the "C" numbers are the museum catalogue numbers, while the four collections without the "C" are our designations.

SM C–166. East side of Groote Eylandt, N.T. Coll. N. Tindale, Aug. 1921.
C–501. Queenscliffe Reef, Kangaroo I., S.A. Coll. W. H. Anderson, registered 1925.
C–502. St Vincent Gulf, S.A. Coll. W. H. Baker.
C–504. Marino Reef, W.A. Coll. W. H. Baker and H. M. Hale, 1923.
C–505. Northern Territory, registered 1925.
C–511. Glenelg, St Vincent Gulf, S.A. Coll. H. M. Hale, Aug. 1920. Collected after storm.
C–515. Queenscliffe Reef, Kangaroo I., S.A. Coll. A. Zietz, 1888.
C–517. Nuyts Arch, S.A. 3–4 fms. Coll. F. Wood-Jones, registered 1925.
C–518. Kangaroo I., S.A. Coll. A. Zietz.
C–805. Queenscliff, Kangaroo I., S.A. Coll. Hale & Tindale, January, 1926. Intertidal from under stones.
C–1066. 5 mi. off Semaphore, S.A. 5 fms. Coll. H. M. Hale.
C–1074. Glenelg, S.A. Coll. H. M. Hale, registered 1926.
SM 1. Coll. W. B. Greenwood, 30/8/09.
2. Hallets Cove, S.A. Coll. J. Formby Collin.
3. Point Lincoln, S.A. Coll. M. Dredge, 29/3/64.
4. Smoky Bay, S.A. Coll. F. Wood-Jones.

COLLECTIONS FROM THE TASMANIAN MUSEUM AND ART GALLERY, HOBART

The preface "TM" is ours; the following designations are Museum catalogue numbers.

TM G1102. Eaglehawk Neck, Tasmania. Sept. 1935.
12877/G51. Kingston Beach, Derwent Estuary, Tasmania. Nov. 1952. Coll. J. R. Cunningham.
12879/G52. Green I., D'Entrecasteaux Channel, Tasmania. 21/7/48.
15121/G325. Point Esperance, Tasmania. 54 ft. 2/3/58. Coll. M. Tobias. From woodwork of wreck.
16630/G425. Near Woody I., D'Entrecasteaux Channel, Tasmania. Coll. L. Hughes, July 1962. From scallop dredge.

COLLECTIONS FROM THE UNIVERSITY OF QUEENSLAND, BRISBANE

These collections were made by various individuals in the Brisbane area, including some attached to the CSIRO; in some cases they lent us the specimens directly, but in some cases the specimens came from the University of Queensland. All will be returned to the University of Queensland, and probably will eventually be placed in the Queensland Museum. The full designation is ours.

UQ 1. Moreton Bay, Qld. Coll. E. Ellway, 25/5/67. Collected from piles at end of Dunwich Jetty, substrate sandy-mud.
2. Moreton Bay. 3–6 fms. Coll. C. R. Smalley, 13/5/68. Collected in one-half hour prawn trawl during day, from channels of a large sponge caught in trawl, substrate sandy-mud.
3. Moreton Bay. Coll. C. R. Smalley, 14/5/68. Dug up on intertidal *Zostera* beds at Dunwich. Shrimp occupied burrows dug about 6 inches into sandy-mud substrate.
4. Moreton Bay. Coll. S. Cook, May 1968. Caught intertidally near jetty at Victoria Point. Substrate mud and rubble.
5. Moreton Bay. Coll. C. Ellway, 25/5/67. From prawn trawl near Dunwich.
6. Moreton Bay. Coll. C. Ellway, 25/5/67. Collected by hand from piles at end of Dunwich Jetty. Substrate sandy-mud.
7. Moreton Bay. Coll. C. Ellway, 25/5/67. From near Dunwich.
8. Moreton Bay. 3 fms. Dredged in morning. Substrate gritty-muddy sand.
9. Jumpinpin, Qld. 5 fms. Coll. T. Helbig, 30/4/68. In bottom of plankton haul. Substrate sandy.
10. Moreton Bay, Qld. 3–6 fms. Coll. C. R. Smalley, 13/5/68. From one-half hour shrimp trawl at day. From channels of large sponge. Substrate sandy-mud.

UQ 11. Moreton Bay. Coll. C. R. Smalley, 17/5/68. Collected by grab off Dunwich Jetty off a vessel moored at jetty. Substrate sandy-mud.
12. Moreton Bay. 7 fms. Coll. Liron, Feb. 1968. From inside large sponge.
13. Moreton Bay. Coll. Moore. Grid Square 72316, *Marelda* Stn. 40.
14. Moreton Bay. 7 fms. Coll. Liron, Feb. 1968. From inside edge.
15. Moreton Bay. Grid square 47, *Marelda* Stn.
16. Moreton Bay. Lot 12.
17. Moreton Bay. 2 1/2 fms. Coll. Moore. Lot 9. *Marelda* Stn. 222.
18. Moreton Bay. 10 fms. Coll. Moore, 4/8/67. Lot 3, Grid Square 73337. *Marelda* Stn.
19. Moreton Bay. Coll. Moore. Lot 11, Grid Square 71. *Marelda* Stn. 445.
20. Moreton Bay. 1967. No further data.
21. Moreton Bay. Coll. A. J. Bruce, 24/9/68. Collected by Pronoxfish at Peel I. from pools amongst oysters and mussel flats.
22. Moreton Bay, Peel I., 0.5 m. Coll. A. J. Bruce from yellow sponge.
23. Norman River at Karumba, Gulf of Carpentaria, Qld. Coll. A. J. Bruce, 1/7/67. From under stones.
24. Gulf of Carpentaria, Qld. Coll. Liron, 14/7/67. From Grid Square 6805. Trawled.
25. Gulf of Carpentaria, Qld. 8 fms. Coll. Moore, 17/11/67. *Santa Maria* Stn.
26. Gulf of Carpentaria, Qld. Coll. Moore, 1/2/68. Grid Square 6798. *Santa Maria* Stn. 38.
27. 1 mi. NE. Mud I., Moreton Bay, Qld. 5.5 fms. Coll. C. R. Smalley, 25–26/3/68. Smalley Coll. No. 8.
28. 1–2 mi. NE. Mud I., Moreton Bay, Qld. 3–6 fms. Coll. C. R. Smalley, 7–8/2/68. Smalley Coll. No. 15. In mud.
29. Same as UQ 28. Smalley Coll. No. 17.
30. Same as UQ 28. Smalley Coll. No. 22.
31. 2–4 mi. E. of lower one-half of Redcliffe Peninsula, Moreton Bay, Qld. 4–6 fms. Coll. C. R. Smalley, 2–3/5/68. Smalley Coll. No. 30.
32. Same as UQ 31. Smalley Coll. No. 40.
33. 2 mi. E. Mud I., Moreton Bay, Qld. Coll. L. Wale from shrimp trawl.
34. 8 mi. E. of Scarborough, Moreton Bay, Qld. 4 1/2 fms. Coll. W. Stephenson, 10/11/61. Sandy bottom.

COLLECTIONS FROM THE NATIONAL MUSEUM OF NATURAL HISTORY, SMITHSONIAN INSTITUTION, WASHINGTON, D.C.

These collections were made by Dr James M. Moulton, of the Department of Biology, Bowdoin College, Brunswick, Maine, and deposited in the Smithsonian Institution by him. The "US" is our prefix; the numbers are the catalogue numbers of the Crustacea section of the Museum.

US 106163. Dunwich, North Stradbroke I., Qld. 3/9/60.
106164. Same as US 106163.
106165. Same as US 106163.
106166. Same as US 106163. Under rocks at low tide.
106167. Same as US 106166. 3/11/60.
123562. Same as US 106166. Intertidal, under rocks in *Callianassa* burrows.
123563. Heron I., Capricorn Group, Qld. 15/11/60. Under beach rock W. side, in damp sand only.
123564. Same as US 123563. 28/1/60. S. side.
123565. Wistari Reef, Capricorn Group, Qld. 30/10/60. Under dead coral on S. side.
123566. One Tree I. Reef, Capricorn Group, Qld. 1/12/60.
123567. Quoin I., N. end, Port Curtis, Qld. 25/1/61. Intertidal zone, under rocks. Rocks and coarse sand.
123568. Unnamed islet, W. side of Facing I., Port Curtis, Qld. 27/1/61. Intertidal, under rocks. Muddy silt, mangrove island.
123569. W. reef, Heron I., Capricorn Group, Qld. 6/10/60. From mid-reef, dead staghorn coral.
123570. Same as US 123569. 20/10/60. 20 yds out, from pit in base of coral head.
123571. Same as US 123569. Low tide, coral head crevice. Western shallows.
123572. N. of Heron I., Capricorn Group, Qld. 5/10/60. From crevices in dead coral.
123573. Same as US 123572. Outer edge of N. reef in dead coral. Larger one under *Tridacna*.

US 123574. Same as US 123572. 9/10/60. Coral heads and roots between island and outer edge of northern reef.
123575. Same as US 123572. 20/10/60. Crevices in coral heads. Western shallows, low tide.
123576. Same as US 123572. 22/10/60.
123577. Same as US 123565.
123578. Same as US 123565. Under dead coral.
123579. Same as US 123565.
123580. Heron I., Capricorn Group, Qld. 19/11/60. Under coral heads in SE. corner.
123581. Same as US 123580.
123582. North West I., Capricorn Group, Qld. 29/2/60. SW. part of reef, under dead coral pieces.
123583. Same as US 123566. Under dead coral pieces.
123584. Same as US 123566. 6/10/60. Reef W. of lab., in dead coral.
123585. Same as US 123565. 10/10/60. S. side, under dead coral.
123586. Same as US 123585.
123587. Same as US 123565. Under coral rocks.
123588. Same as US 123565. 19/10/60. Crevices in dead coral bases.
123589. Same as US 123565. 20/10/60. S. side, under dead coral.
123590. Same as US 123565. 21/10/60. Western reef, coral head crevice.
123591. Same as US 123565.
123592. Same as US 123565. 14/11/60. E. side, dead coral, living coral base 20 ft below low tide.
123593. Same as US 123563. 9/10/60. Under coral heads, outermost edge of reef N. of island.
123594. Same as US 123593.
123595. Same as US 123565.
123596. Same as US 123565.
123597. Same as US 123565.
123598. Same as US 123565. 18/12/60. SE. corner of reef, under dead coral.
123599. Same as US 123565.
123600. Same as US 123565. 9/10/60. N. reef between island and outer edge of reef. Coral heads and roots.
123601. Same as US 123565. 5/10/60. Reef edge.
123602. Facing I., W. side, Port Curtis, Qld. 26/1/61. Intertidal, under rocks. Rocks and coarse sand.
123603. Dunwich, North Stradbroke Is., Qld. 10/4/61. Intertidal area under rocks in *Callianassa* burrows.
123604. E. side, Port Curtis, Qld. 27/1/61. Coral debris 5 ft below low tide level.
123605. Same as US 123565. Western Reef in dead coral.
123607. Same as US 123604.
123608. Same as US 123565. 30/10/60. Under coral head.
123609. Same as US 123565. 28/11/60. S. side, under beach rock in most sand.

COLLECTIONS FROM NATIONAL MUSEUM OF VICTORIA, MELBOURNE

This collection was without museum catalogue numbers, and we have assigned he full designation.

VM 1. Western Port Bay, Victoria. Coll. S. W. Fulton, 23/5/1906.
2. Green I., Qld. Coll. A. Tubb, Jan. 1935.
3. Mordialloc Beach, Victoria. Coll. W. Kershaw, Nov. 19, 1888.
4. Portland, Victoria. From C. Kurtze, 20/6/1952.
5. South Australia. Cummins, 1902.
6. Mordialloc Beach, Victoria. Pres. C. Johnston, 25/3/1907.
7. Point Cook, Victoria. Coll. C. L. Barrett, 1/4/1905. From dredge.
8. Portland, Victoria. Coll. N. Learmonth, 24/8/1950.
9. S. Brighton, Victoria. Pres. W. Kershaw.
10. Cheltenham, Victoria. Coll. W. Kershaw, 20/7/1891. Found on beach after storm.
11. Same as VM 10. 21/7/1891.
12. San Remo, Victoria. Coll. A. Tubb, 17/10/1934.
13. Western Port, Victoria. Coll. J. H. MacPherson, 2/9/1957. From SE. Oyster beds.
14. Mordialloc Beach, Victoria. May 1877.
15. Newport Power House, Victoria. Coll. H. A. Morrison, 21/7/1949.

VM 16. Portland, Victoria. Coll. Mr Butler, Dec. 1883.
17. Coast of Adelaide to Kangaroo I., S.A. Coll. R. H. Cummins, 1902.
18. Same as VM 14.
19. Barrier Reef off Cape York, Qld. Coll. C. French, Sept. 1881.
20. Same as VM 16. Oct. 6, 1879.
21. Phillip I., off Cowes, Victoria. 16–20 fms. 1/6/1951.
22. Port Willunga, S.A. Coll. R. H. Cummins, 6/4/1906. Fulton collection.
23. Elliot Heads near Bundaberg, Qld. Dec. 1963.
24. Beaumaris, Victoria. 1–2 fms. Coll. S. W. Fulton, 24/11/1900. In rotten reef.
25. Norfolk I.
26. Same as VM 24. In rocks, dredged.
27. San Remo, Western Port, Victoria. Coll. Coghill, 28/1/1909.
28. Hobson's Bay, Victoria. Coll. J. A. Kershaw, 1901.
29. Low Isles, Great Barrier Reef, Qld.
30. Off Rhyll, Western Port, Victoria.
31. Normanville, S.A.
32. St Vincent Gulf, S.A. Coll. R. Cummins, 1902.
33. Port Albert, Victoria. Coll. Mattingly, 1903. Dredged.
34. New South Wales, July 1892. Purchased from Mr Brown, N.S.W.
35. Western Port Bay, Victoria. Pres. S. W. Fulton, 23/5/1906.
36. Tom Thumb Lagoon, Port Kembla, N.S.W. Coll. A. G. Hamilton, March 1902.
924, 925, 935, 948, 949, 956, 957, 962. Port Phillip Bay, near centre, Victoria. 22–24 m. 1970–71. Soft silty substrate. [These collections were made during the Port Phillip Bay Zoobenthos Survey by the Marine Pollution Section, Fisheries and Wildlife Department of Victoria, and will be stored, in part, in the National Museum. We use the Museum prefix followed by the Fisheries and Wildlife station numbers.]
941. Port Phillip Bay, Western Arm, Victoria. 9 m. 1970. Soft silty substrate.

COLLECTIONS FROM THE WESTERN AUSTRALIAN MUSEUM, PERTH

All numerical designations are of the Museum, to which we have assigned the prefix "WM".

WM 22–65. Near National Fitness Camp, Point Peron, W.A. Coll. R. W. George, 1/12/61.
23–65. Carnarvon Area, W.A. Trawled. 1/12/69.
23–65a. 2 mi. WNW. of Cottesloe, W.A. (near buoy). 2 fms. Coll. R. W. George on *Davena*, –/15/60.
24–65. Channel Rock Buoy, Darwin, N.T. Coll. R. E. Hannan, 1/9/63.
25–65. Between Malus and Gidley I., Dampier Arch., W.A. Coll. Royce on *Davena*. Sand and coral.
26–65. Same as 25–65, 1/6/60.
29–65. Pelsart Group, Houtman Albrolhos, W.A. Coll. J. Allahis, 13/6/60. In crayfish pot.
30–65. 3–4 ft off E. end of Delambre I., Dampier Arch., W.A. Coll. B. R. Wilson on *Davena*, 5/5/60.
31–65. Garden I., W.A. Coll. L. R. Thomas, 14/1/64. On reef flats.
32–65. Rottnest I., W.A. Coll. G. Dittmer, 1/7/65. From sponge.
33–65. E. of Pelsart I., Houtman Abrolhos, W.A. Dredged at 20 fms. Coll. M. Cramer, –/6/62.
34–65. Exmouth Gulf or Shark Bay, W.A. Trawled. Coll. R. M. McKay on the *Peron*. Winter, 1960.
35–65. NE. of Garden I., W.A. 15 ft. Coll. P. Barrett-Lennard, 14/3/59. From an old boom pile.
36–65. Yardie Creek Station, North West Cape, W.A. Coll. Douglas and Mees, 2/8/59. Under stones on sandy beach.
37–65. Dirk Hartog I., W.A. Coll. J. Sells, –/4/57. From crayfish pots.
38–65. 7 mi. SW. of Bunbury, W.A. 11 fms. Coll. F. R. V. *Lancelin*, 13/4/63.
39–65. Yule Point, N. of Cairns, Qld. Coll. G. F. Mees, 11/10/61.
40–65. Careening Bay, Garden I., W.A. Coll. B. R. Wilson and Marine Group, 26/11/61.
41–65. Shark Bay, 40 mi. SW. of Carnarvon, W.A. Trawled. Coll. A. Snell, 1/6/60.
42–65. Lancelin I., W.A. Coll. Neptune Submariners, 14/1/58.
43–65. Point Quobba, W.A. 24° 30′ S., 113° 24′ E. Coll. Jan. 59.
44–65. Exmouth Gulf, W.A. Coll. W. Dall, 10/9/53.
45–65. NW. of Jurien Bay, W.A. 30° 00′ S., 114° 32′ E. Beam Trawl at 70–75 fms. CSIRO Sta. 3, 25/1/64. Sponge and bryozoa.

WM 47–65. Victoria Station, Cottesloe, cable station, Perth, W.A. Coll. W. H. Butler, 16/3/61.

48–65. Trawled off Mandurah, W.A. Coll. Poole Bros, 4/1/63.

49–65. D'Estrees Bay, S.A. Sample 47. 5/4/53.

51–65. Carnac I., S. reef platform, W.A. Coll. E. P. Hodgkin, 20/12/61.

52–65. South Reef, Penguin I., W.A. Coll. B. Lindsay, 14/11/64. From sponge.

53–65. North of Darwin, N.T. Coll. R. Kersting, 12/11/19 ?. From buoys and beacons near light house.

54–65. W. of Bluff Point, Geraldton, W.A. 24° 40′ S., 113° 03′ E. 20 fms. CSIRO Sta. 131. 22/8/68.

55–65. Exmouth Gulf, W.A. Trawled at 1–10 fms. Coll. R. W. McKay on the *Peron.* Winter, 1960. From sponge.

58–65. Same as WM 35–65.

60–65. W. side of Exmouth Gulf, W.A. 8–9 fms. 23/9/53. From sponge.

61–65. Panchoran Buoy, 13/7/61.

62–65. Woody I., Houtman Albrolhos, W.A. Coll. R. P. McMillan.

63–65. SW. of Geraldton, W.A. 29° 05′ S., 113° 56′ E. 71–81 fms. CSIRO Sta. 54, 16/2/64.

64–65. NW. of Bluff Point, W.A. 27° 40′ S., 113° 20′ E. 7 1/2 fms. CSIRO Sta. 208, 10/10/63.

65–65. Between Long and Table Is, NW. of Onslow, W.A. F. R. V. *Lancelin,* 1/8/63. Coarse sand and dead shells.

69–65. N. of Leschenault, W.A. 47–49 fms. Coll. CSIRO 11/10/63.

70–65. Cockatoo I., W.A. Coll. N. Hoffman, March 1963. In dead coral cracks and hollows.

71–65. NW. of Bluff Point, W.A. 27° 40′ S., 113° 03′ E. 70 fms. CSIRO Sta. 31, 22/8/63.

72–65. 5 mi. NE. end of Rottnest I., W.A. 19 fms. Coll. R. W. George on *Davena.*

73–65. Cable Beach, Broome, N. W.A. Coll. W. Goode on the *Dorothea,* 6/10/62.

76–65. Point Peron, W.A. Coll. D. G. Bathgate, 11/7/62. In limestone from reef.

77–65. Zeewyk Channel, Houtman Abrolhos, W.A. 21 fms. Coll. F. R. V. *Lancelin,* 6/3/63.

79–65. 60 mi. W. and N. Bedout I., W.A. Dredged at 25 fms. Coll. R. W. George on the *Dorothea.*

81–65. 23 mi. W. and N. of Bedout I., W.A. Dredged at 25 fms. Coll. R. W. George on the *Dorothea,* 12/10/62.

82–65. Lancelin I., W.A. Coll. R. Ackerman, –/3/64.

83–65. Cockburn Sd, W.A. 2 mi. W. of naval base. Dredged in 10 fms. Coll. P. Cawthorn on *Lancelin.*

84–65. NNW. of Busselton Jetty, W.A. Dredged at 5 fms. Coll. B. R. Wilson and J. Seabrook on *Lancelin.*

85–65. Near National Fitness Camp, Point Peron. Coll. R. W. George, 1/11/61. In "worm" rock.

86–65. 5 mi. W. of North Beach, Perth, W.A. 50 ft. Coll. D. Blair, 9/9/61. In sponge.

87–65. Kwinana, Cockburn Sd, W.A. 200–300 yds NW. off #2 buoy. Coll. B. R. Wilson, 10/1/58.

88–65. NW. of Bluff Point, W.A. 27° 18′ S., 13° 16′ E. 54 fms. CSIRO Sta. 204, 9/10/63.

89–65. Yampi Sd, W.A. Coll. G. A. Robinson, 1/19/60.

90–65. W. of Geraldton, W.A. 28° 14′ S., 113° 28′ E. 60 fms. CSIRO Sta. 40, 4/2/64.

91–65. NW. of Carnarvon, W.A. 22° 59′ S., 113° 25′ E. Beam Trawl at 71 fms. CSIRO Sta. 17, 31/1/64.

92–65. Triggs I., near Perth, W.A. Coll. W. H. Butler, 20/4/61.

93–65. Off Cleveland Cape, Qld. Dredged in 16 fms. Coll. W. Goode, 24/11/63.

94–65. NW. of Cape Naturaliste, W.A. 33° 40′ S., 114° 28′ E. 75 fms. CSIRO, Aug. 1963.

95–65. Near bar of South Passage, Shark Bay, W.A. Coll. R. W. George on *Davena,* 14/4/60.

96–65. Cockburn Sd, W.A. Coll. F. V. *Dante,* 9/2/57.

97–65. Emu Point Channel, Albany, W.A. Coll. R. W. George, 15/1/59.

98–65. Reef flat Yanchep, W.A. Coll. B. Wilson, 27/1/59. Low tide, under stones.

99–65. Same as WM 85–65, 1/10/61.

101–65. Roeburne, W.A. Coll. C. Lambert, 21/9/59. Under stones on reef flat.

102–65. "Flat Rocks", Greenough, near Geraldton, W.A. Coll. B. R. Wilson, 23/8/58.

WM 103–65. Busselton, W.A. Coll. W. H. Butler, –/3/62.
104–65. Heron I., Capricorn Group, Qld. Coll. R. W. George, 5/12/61. Reef flat, beach edge under rocks.
105–65. Same as WM 92–65.
106–65. Dirk Hartog I., W.A. Coll. J. Sells, –/3/57. From crayfish pot.
107–65. Denham, Shark Bay, W.A. Coll. B. R. Wilson, 29/12/59.
108–65. Same as WM 95–65, 14/5/60.
109–65. Same as WM 92–65, 14/3/61.
111–65. 1–2 mi. W. of Seal I., King George Sd, W.A. Coll. R. W. George, –/3/62.
112–65. Esperance Bay, W.A. Coll. W. H. Butler, 20/11/59.
113–65. Rockingham, near Perth, W.A. 8/2/58. From rocks near old piles.
114–65. Jervois Groyne, Cockburn Sd, W.A. Cockburn Sd Survey, 13/12/58. From coral rock N. of groyne.
115–65. Same as WM 95–65. 14/5/60.
116–65. Same as WM 95–65. 14/5/60. 6 fms. Coll. with Honolulu dredge. Sand and gravel.
117–65. Fremantle, W.A. WM collection, –/10/12. From jetty piles.
118–65. Wreck Point, Southern Group, Houtman Abrolhos, W.A. Coll. A. Robinson, 20/4/58.
119–65. Same as WM 98–65.
120–65. Pidgeon I., Wallabi Group, Houtman Abrolhos, W.A. Coll. P. Barrett-Lennard, –/5/59. From crinoids.
121–65. Busselton, W.A. Coll. W. H. Butler, 1/3/62.
122–65. No data, almost certainly northern W.A. Coll. K. Godfrey on *Lancelin*, 1954.
123–65. Same as WM 107–65.
125–65. Point Gregory, NW. side of Peron Peninsula, Shark Bay, W.A. Coll. B. R. Wilson, 1/1/60.
126–65. Lancelin I., W.A. Coll. J. Shea, Dec. 1965. On deck from cray pots and sponges.
127–65. Good Friday Bay, Houtman Abrolhos, W.A. Coll. F. R. V. *Lancelin*, 26/2/63.
128–65. Same as WM 95–65, 14/5/60.
129–65. W. of Lancelin I., W.A. 31° 05′ S., 114° 55′ E. CSIRO Sta. 46, 5/2/64.
130–65. Port Gregory Reef, NW. side of Peron Peninsula, Shark Bay, W.A. Coll. B. R. Wilson, 6/12/62. Under stones at low tide.
131–65. Yampi Sd. Coll. G. A. Robinson, –/9/60. Low tide.
132–65a. WNW. Rottnest I., W.A. 90–94 fms. Coll. R. W. George on *Bluefin*, 4/8/62.
132–65b. Point Gregory, NW. side of Peron Peninsula, Shark Bay, W.A. Coll. B. R. Wilson, 1/1/60. Under stone on limestone reef flat at low tide.
133–65. Same as WM 120–65. –/5/59.
134–65. North of Peron Flats, Shark Bay, W.A. Coll. Poole Bros, –/7/62.
135–65. Eagle Bay, Cape Naturaliste, W.A. Coll. B. R. Wilson, 7/8/63. Under intertidal granite boulders.
136–65. Same as WM 114–65. 3/12/61.
139–65. NW. end of Rosemary I., Dampier Arch., W.A. Coll. B. R. Wilson and G. W. Kendrick, 24/8/61.
140–65. Off Garden I., W.A. Beam Trawl, 2 fms. Coll. CSIRO *Lancelin*, –/7/63.
141–65. Hopetoun, N. Jetty, W.A. Coll. R. W. George, 9/1/59. Granite rocks, low tide.
142–65. S. W. Herald Cay, Qld. 14/11/61.
143–65. Lancelin I., W.A. Coll. J. McKay, March or April 1958. On cray pots.
144–65. Gidley I., Dampier Arch., W.A. Coll. Royce on *Davena*, 1/6/60. From coral rubble.
145–65. W. of Rottnest I., W.A. 32° 00′ S., 115° 08′ E. 75 fms. CSIRO Sta. 154.
147–65. 1/2 mi. SE. Mistaken I., King George Sd, Southern W.A. 17 fms. Coll. B. R. Wilson and G. W. Kendrick.
152–65. Same as WM 139–65. 27/8/61.
155–65. Norfolk I., limestone platform at Kingston. Coll. E. P. Hodgkin, 19/9/61. Washed from *Caulerpa*.
156–65. Between Gidley and Rosemary Is, Dampier Arch., W.A. Muriel King Exped. Coll. Royce on *Davena*, 3/15/60.
159–65. Owen Anchorage, trawled off Fremantle power house, W.A. Coll. R. W. George on *Lancelin*, 6/12/59.
160–65. NW. of Point Cloats, W.A. 22° 52′ S., 113° 29′ E. 73 fms. CSIRO Sta. 178, 6/10/63.
161–65. Cape Inscription and Cape St Creig, Shark Bay, W.A. 38 fms. Coll. R. W. George on *Davena*, 16/5/60.

WM 162–65. Exmouth Gulf, W.A. Trawled. Coll. Poole Bros, Oct.–Nov. 1958.
163–65. Cable Station Victoria St, Cottesloe, W.A. Coll. W. H. Butler, 16/3/61.
164–65. Point Peron, W.A. 6 ft. Coll. W. H. Butler, 26/6/60.
165–65. West Point, Darwin, N.T. Coll. R. I. Hannan, 4/11/63. Low water.
166–65. Good Friday Bay, Houtman Abrolhos, W.A. Dredged 5 fms. Coll. F. R. V. *Lancelin*, 3/3/65.
167–65. Shark Bay, W.A. F.R.V. *Peron*, Sta. H. 137. 2/7/62.
168–65. Monkey Mia, Shark Bay, W.A. Coll. A. Kalnias, 25/3/50. In sand at low tide.
169–65. Same as 166–65, 9/7/62.
170–65. N. end Oyster Harbour, W.A. 20° 23′ S., 118° 29′ E. 3 fms. Coll. B. R. Wilson, 2/7/65. In mud.
171–65. Same as WM 95–65. 14/5/60.
172–65. Port Walcott, W.A. 20° 39′ S., 117° 10′ E. 8 fms. Coll. Royce on *Davena*, 3/6/60.
173–65. Shark Bay, 40 mi. SW. of Carnarvon, W.A. Trawled. Coll. R. Snell, 1/6/60.
174–65. Off Parker Point, Rottnest I., W.A. Coll. Mr Pollard, 7/8/63.
175–65. Same as WM 92–65, 20/3/61.
176–65. Cockburn Sd, 2 mi. off Rockingham, W.A. Coll. R. Slack-Smith and G. W. Kendrick, 6/1/65.
177–65. Same as WM 176–65.
178–65. Albany, W.A. From octopus stomach collected at town jetty, Oct. 1965.
179–65. Shark Bay, W.A. Coll. by F. R. V. *Peron* haul 5, 2/3/62.
180–65. Lancelin I., W.A. Coll. J. Shea, –/12/56. On deck from craypots and sponges.
181–65. Rat I., Houtman Abrolhos, W.A. Coll. F. Greco, 10/3/63. Inside coral piece caught on crayfish pot rope in shallow water.
182–65. 5 mi. E. of North I., Houtman Abrolhos, W.A. Honolulu dredge. Coll. R. W. George on *Davena*, 13/5/60. Sea weed, coral, sponge.
183–65. Between "Y" and Whalebone I., Exmouth Gulf, W.A. Coll. K. Godfreys, 5/8/53.
184–65. SW. of Geraldton, W.A. 29° 5′ S., 113° 56′ E. 71–81 fms. CSIRO Sta. 54, 16/2/64.
185–65. Yampi Sd, N. W.A. Coll. G. A. Robinson, 1/1–/59.
186–65. 7–8 mi. N. of Long I., off Onslow, W.A. Coll. B. R. Wilson on *Davena*, 17/6/60.
187–65. Palm Beach Jetty, Cockburn Sd, W.A. Zool. Dept Univ. W.A., 16/4/59.
188–65. Between Green I. and Cervantes I., W.A. Coll. R. H. Amm, early 1963.
189–65. Shark Bay, Block 16, W.A. Coll. F. R. V. *Peron*, 7/8/62.
190–65. Shark Bay, W.A. Coll. F. R. V. *Peron* Haul 147, 13/7/63.
191–65. Yampi Sd, W.A. Coll. G. A. Robinson, –/2/61. Reef at low tide.
192–65. W. of Dirk Hartog I., W.A. 25° 54′ S., 112° 38′ E. Beam trawl at 70–72 fms. CSIRO Sta. 35, 3/2/64.
193–65. Reef bottom, near flashing light, Port Hedland, W.A. Coll. Mr B. Duncan, –/7/63.
196–65. Patches Point Charles, 12 mi. from Darwin, N.T. Coll. R. J. Hannen, 13/11/63.
197–65. Same as WM 114–65, 1/12/55.
198–65. 2 mi. E. of E. end of Rottnest I., W.A. 9 fms. Coll. R. W. George on *Davena*.
199–65. Exmouth Gulf, W.A. Trawled 6 fms. Coll. CSIRO, Oct. 1955.
200–65. W. side of Friday Bay, Houtman Abrolhos, W.A. Dredged 10–15 fms. Coll. F. R. V. *Lancelin*, 8/3/63.
201–65. 3 mi. NW. of Lodge Point, W.A. 34° 28′ S., 119° 13′ E. 8–9 fms. Coll. I. Patterson, –/1/61. From craypot.
202–65. Beagle I., W.A. 29° 40′ S., 114° 52′ E. 33 ft. Coll. Poole Bros, March–April, 1959. From crayfish pots or ropes.
203–65. Same as WM 95–65. Honolulu Dredge at 6 fms. 14/5/60. Sand and weed.
204–65. W. side of North West Cape, W.A. Coll. H. Roberts, –/6/61. Under stones.
205–65. Cockburn Sd, W.A. 8 ft. Marine Naturalist Club. Inshore.
208–65. Jetty area, Woodman's Point, near Perth, W.A. Coll. R. W. George, 19/2/61. Living under sea urchins *Heliocidaris* sp.
209–65. 2 mi. after Legendre Is, Dampier Arch., W.A. Coll. Wilson on *Davena*, 9/11/60.
210–65. Port Hedland, W.A. Coll. Mr Brown, –/9/61. Among sponge and rubble.
211–65. Point Peron, W.A. Coll. W. H. Butler, 9/4/60. In "worm rock".
212–65. Esperance, W.A. Coll. W. H. Butler, –/11/60.
213–65. SW. of Geraldton, W.A. 29° 49′ S., 114° 24′ E. 70–72 fms. CSIRO Sta. 214, 11/10/63.
214–65. Cockburn Sd, Jervois Groyne, W.A. Coll. G. W. Kendrick, 20/10/63. Intertidal, under stones.

WM 217–65. 2 mi. SW. of Peak I., W.A. Honolulu dredge at 10 fms. Coll. B. R. Wilson on *Davena*, 8/6/60.
220–65. Shark Bay, W.A. Pres. 1/7/64.
221–65. Yampi Sd, W.A. Coll. G. A. Robinson, –2/3/60.
222–65. Same as WM 211–65, 8/11/62.
223–65. NW. of Bluff Point, W.A. 27° 18′ S., 113° 16′ E. 54 fms. CSIRO Sta., 9/10/63.
225–65. Wood I., Houtman Abrolhos, W.A. Coll. R. P. McMillan, –/5/63.
226–65. 40 mi. W. of Cape Jaubert, W.A. 23 fms. Coll. R. W. George on *Dorothea*, 13/10/62. On sponge.
227–65. Yanchep, W.A. 31° 33′ S., 115° 41′ E. 15 fms. Coll. B. Hughill, –/5/59.
228–65. Same as WM 95–65, 14/5/60.
229–65. Same as WM 92–65, 14/3/61.
230–65. SW. of Point Cloats, W.A. 23° 05′ S., 113° 23′ E. 73 fms. CSIRO Sta. 182.
231–65. 3–4 mi. off end of Delambre I., Dampier Arch. Coll. B. R. Wilson on *Davena*, 5/6/60.
233–65. NW, Malus Is, Dampier Arch., W.A. 10 fms. Coll. Royce on *Davena*, 31/5/60.
235–65. Woody I., Houtman Abrolhos, W.A. Coll. R. P. McMillan.
237–65. Bay of Exmouth Gulf—data uncertain, W.A. Coll. K. Godfrey of CSIRO.
238–65. Eagle Hawk I., Dampier Arch., W.A. Coll. B. R. Wilson, 13/6/60.
239–65. Cockburn Sd, Sta. 31. Coll. W. A. Naturalist Club, 22/2/59.
240–65. Point Peron, W.A. Coll. B. R. Wilson, 1/9/63. Among "worm" rocks.
241–65. Shark Bay, W.A. Coll. Poole Bros, –/7/63.
242–65. Kuri Bay, northern W.A. Coll. Kuri Pearl Ltd, –/17/64.
243–65. Shark Bay, W.A. Coll. by F. R. V. *Peron*, block 16, 8/7/62.
244–65. Shark Bay, W.A. Coll. by F. R. V. *Peron*, haul 1, 1/3/62.
245–65. Heron I., Capricorn Group, Qld. Coll. R. W. George, 23/6/61. From reef flat.
246–65. NW. of Rottnest I., W.A. Dredged 90–91 fms. Coll. R. W. George on *Bluefin* Sta. 32, 5/8/62.
247–65. 10–20 mi. W. of LaGrange, W.A. 12–15 fms. Coll. R. W. George on *Dorothea*, 13/10/62.
248–65. 1 1/2 mi. W. of S. end of Garden I., W.A. Dredged at 10 fms. Coll. R. W. George on *Bluefin*, 13/10/62.
250–65. NW. of Rottnest I., W.A. Dredged at 37 fms. Coll. R. W. George on *Bluefin* 12/8/62. From sponge.
251–65. Riddell Beach, Broome, W.A. Coll. R. Baird and M. MacDonald, 28/12/61. Intertidal, under rocks.
252–65. Between Roebourne and Onslow, W.A. Coll. R. B. Sharp, 8/9/62. Intertidal.
255–65. NW. of Rottnest I., W.A. 100–103 fms. Coll. R. W. George on *Bluefin*, 14/8/62. From sponges.
256–65. Port Hedland, W.A. Coll. Capt. Beamish, 5/7/63. Intertidal.
257–65. Jervois Groyne, Cockburn Sd, W.A. Coll. B. R. Wilson, 3/12/61.
258–65. 1 1/2 mi. W. of S. end of Garden I., W.A. 10 fms. Coll. R. W. George on *Bluefin*, 13/8/62.
265–65. Garden I., near Perth, W.A. 100 yds offshore. Coll. R. Dawson and Marine Group, 25/11/61. In coral.
266–65. Garden I., Careening Bay, under naval jetty, W.A. Coll. Marine Group and Nats Club, 1/3/59. From sponge.
267–65. Garden I., W.A. Beam trawl. CSIRO *Lancelin*, –/7/65.
268–65. Garden I., W.A. 15 ft. Coll. P. Barrett-Lennard, 1959.
269–65. W. of W. end of Rottnest I., W.A. Dredged in 74–75 fms. Coll. R. W. George on *Bluefin*, 10/8/62.
270–65. WNW. Rottnest I., W.A. Dredged 95–96 fms. Coll. R. W. George on *Bluefin*, 4/8/62. On sponges.
271–65. Bunbury, W.A. Coll. W. H. Butler, 3/65.
272–65. Mouth of Murchison River, near Gantheaume Bay, W.A. Coll. I. McDonald, –/1/63.
273–65. S. side of Point Peron, W.A. Coll. B. R. Wilson, 7/12/58. Among worm tubes.
274–65. Exmouth Gulf, W.A. Dredged at 2 fms. Coll. F. R. V. *Lancelin*, 28/8/63.
275–65. Port Hedland, W.A. Coll. A. McKay via P. Barrett-Lennard, 3/5/59. Intertidal.
276–65. Port Dennison, W.A. 29° 17′ S., 114° 53′ E. Coll. B. R. Wilson, 24/8/58.
277–65. Cable Beach, Broome, W.A. Coll. M. McDonald, 27/12/61. In rock pools.
278–65. Yampi Sd, W.A. Coll. G. A. Robinson, –/12/60.
279–65. W. approaches to Mermaid Str., Dampier Arch., W.A. Coll. Royce on *Davena*, 27/5/60.
281–65. Adele I., W.A. Coll. W. Goode on *Dorothea*, 18/1/62. From large clam shell.

WM 282–65. Cockatoo I., W.A. 16° 06′ S., 123° 08′ E. Coll. N. Hoffman, Nov. 1962. From among crinoids.
284–65. Shark Bay, W.A. Coll. Poole Bros on *Bluefin*, –/14/63.
285–65. Dampier Arch., W.A. Coll. Neptune Submariners.
286–65. Point Gregory, NW. side of Peron Peninsula, Shark Bay, W.A. Coll. B. R. Wilson, 1/1/60.
288–65. Palm Beach, Rockingham, W.A. Coll. P. Barrett-Lennard, 1959. From jetty piles.
289–65. Same as WM 211–65. –/6/59.
290–65. W. of Carnarvon, W.A. 24° 59′ S., 112° 27′ E. 71 fms. CSIRO Sta. 197. 8/10/63.
292–65. Cockatoo I., W.A. 16° 06′ S., 123° 08. E. Coll. N. Hoffman, mid-1963.
293–65. N. side of Triggs I., W.A. Coll. W. H. Butler, 8/12/63. From sponge.
294–65. Swan River, Perth, W.A. Coll. G. Oloughta, –/13/65.
295–65. Canning River, near Fremantle, W.A. Coll. K. Sheard, –/12/65.
296–65. Yanchep reef flat, W.A. Coll. B. R. Wilson, 27/1/59.
297–65. Same as WM 211–65. –/6/59.
298–65. Same as WM 211–65. –/6/59.
299–65. Yampi Sd, W.A. Coll. G. A. Robinson, –/12/61.
300–65. Same as WM 211–65. –/6/59.
301–65. NE. of Garden I., W.A. Coll. P. Barrett-Lennard, 15/3/50. On old boom piles.
302–65. Same as WM 301–65. 4/3/59.
304–65. Off Cheyney Beach, Cheyne Point, W.A. 33° 54′ S., 122° 32′ E. Coll. S. Barker, –/5/59.
305–65. Busselton, W.A. Coll. Univ. W.A., 3/4/59.
44–49. Mandurah, W.A. Coll. P. H. Gard, 2/4/49.
93/94–96. Swan River, Fremantle, W.A. Coll. R. H. Holland, 3/6/46.
153/173. Bathurst Point, Rottnest I., W.A. Coll. L. Glauert, Jan. or Feb. 1931.
251–78–32. Cottesloe, W.A. Coll. L. Glauert, July 1932.
368/9. Bathurst Point, Rottnest I., W.A. Coll. L. Glauert, Feb. 1930. Found living under urchin *Heliocidaris erythrogamma.*
403/5–38. Swan River, Perth, W.A. Coll. F. E. Capstick, 26/5/38.
409/11–30. Bathurst Point, Rottnest I., W.A. Feb. 1930.
4985. Between Fremantle and Geraldton, W.A. Trawled F.I.S. *Endeavour.* Coll. W. B. Alexander, 1912.
4986. Same as WM 4985.
6052. Fremantle, W.A. Coll. W. B. Alexander, Nov. 1912. From piles of old jetty.
8752. Garden I., W.A. Coll. W. B. Alexander and Mr Justice Burnside's party, 14/1/14.
8972. Broome, W.A. Coll. W. B. Alexander, Oct. 1914.
8973. Same as WM 8972. Oct. 1929.
9522. Rottnest I., W.A. Coll. Chief Inspector Fisheries, Jan. 1920.
9982. Cottesloe, W.A. July 1922.
9991. Cottlesloe, W.A. Coll. L. Glauert, 14/8/22. From dead sponge.
10011. Cottesloe, W.A. Coll. L. Glauert, 2/7/22. From *Posidonia.*
10199/10208. Freshwater Bay, off Swan River, W.A. Coll. C. L. Glauert, 26/12/22.
10229–34. Same as WM 10199/10208. Coll. A. E. Wear, 1923.
10274. Same as WM 10229–34.
10380. Cottesloe, W.A. Coll. L. Glauert, June 1923. From sponge.
10381. Same as WM 10380.
10410. Same as WM 10380.
10467. Same as WM 10011. 12/12/22. From living sponge.
10468. Same as WM 10410. July 1928.
10472. Same as WM 9991. 1928.
10481. Same as WM 9991. 21/1/23.
10487. Same as WM 9991. 2/6/23.
10570. Same as WM 10410.
10571/72. Same as WM 10410.
10591/92. Same as WM 10410.
10876. Point Gantheaume, Broome, W.A. Coll. W. C. Mansbridge, 21/2/24.
11100/1. Same as WM 10410. Sept. 1924.
11129/30. Same as WM 9991. Dec. 1924.
11644. Freshwater Bay, off Swan River, W.A. Coll. Mr Justice Burnside, April 1926.
11664, 65, 70, 71, 72, 73. Canning River, Fremantle, W.A. Coll. Capt. Abjornson, –/6/26.
11788. Swan River, Fremantle, W.A. Coll. D. McKenna, 14/8/26.
12112. North Beach, W.A. 31° 52′ S., 115° 45′ E. Coll. L. Lullfitz, 4/6/27.

WM 12822–12823. Bathurst Point, Rottnest I., W.A. Sept. 1928. Reef.
15057. Swan River, Fremantle, W.A. Coll. H. Wood, –/1/29.
15108/9. Swan River, Fremantle, W.A. Coll. I. Galeman, Feb. 1929.
108–60. Garden I., W.A. Coll. by foreman, –/30/24.
115–33. Same as WM 12112. Coll. Mr Webb.
120–37. Swan River, Fremantle, W.A. Coll. A. R. Stephenson.
169–37. Swan River, at Crawley, W.A. Coll. H. McHall, 7/6/37.
173–60. Houtman Abrolhos, South Group, W.A. 6/8/60.
209–57. SE. end Dirk Hartog I., W.A. Coll. B. R. Wilson, –/1/57.
270–52. Swan River, Fremantle, W.A.
338–39. Bunbury, W.A. Coll. T. K. Moriarty, 6/3/39.
449–32–454–32. Swan River, Fremantle, W.A. Coll. F. E. Remist.
497–39. Swan River at narrows, Fremantle, W.A. Coll. Mrs Murfitt, 2/39.
583–31. Same as WM 9991, 27/6/31.
605–39. Swan River at Crawley, W.A. Coll. 7/10/39.
759–30. Canning Bridge, Swan River, Fremantle, W.A. Coll. 24/2/30.

NATIONAL MUS
16 JUL 197
OF VICTORI

Nelima Doriae (Canestrini), a South European Harvestman in Australia and New Zealand (Arachnida, Opiliones, Phalangiidae)

By Jürgen Gruber, Naturhistorisches Museum Wien, Austria, and Glenn S. Hunt,

School of Zoology, University of New South Wales, Sydney

Figures 1–4. Manuscript received, 6th March, 1972

SYNOPSIS

Nelima doriae (Canestrini) (Phalangiidae, Leiobuninae), a southern European harvestman, has been introduced to Australia and New Zealand. Previously it had been described as a new endemic Australian species, *Nelima dunni* Forster. Later it was wrongly made the type of a new monotypic genus, *Nodala* Forster (subfamily Megalopsalinae).

General comparisons are made between introduced and European populations. The introduced populations seem to resemble the Italian-Jugoslavian forms most closely. Significant differences in leg and scute length in Australian forms are noted.

Harvestmen species transported by human agency from one country to another are tabulated along with notes on their adopted habitats. European species in the subfamily Phalangiinae (Phalangiidae) are most often involved, with transport either occurring within the north-temperate zone or across the tropics with invasion of the south-temperate zone.

INTRODUCTION

Many animals have been transported by man from one country to another, often accidentally and without his knowledge. Some have been regarded as endemic and redescribed as "new species".

An example is the phalangiid harvestman, *Nelima doriae* (Canestrini), a south European species introduced to Australia and New Zealand but described as a new species, *Nodala dunni*, by Forster (1947; 1949).

An examination by the authors of Forster's types plus additional material from both hemispheres has shown these two nominal species to represent different populations of the same species.

Family **PHALANGIIDAE**

Subfamily **LEIOBUNINAE**

Genus **Nelima** Roewer, 1910

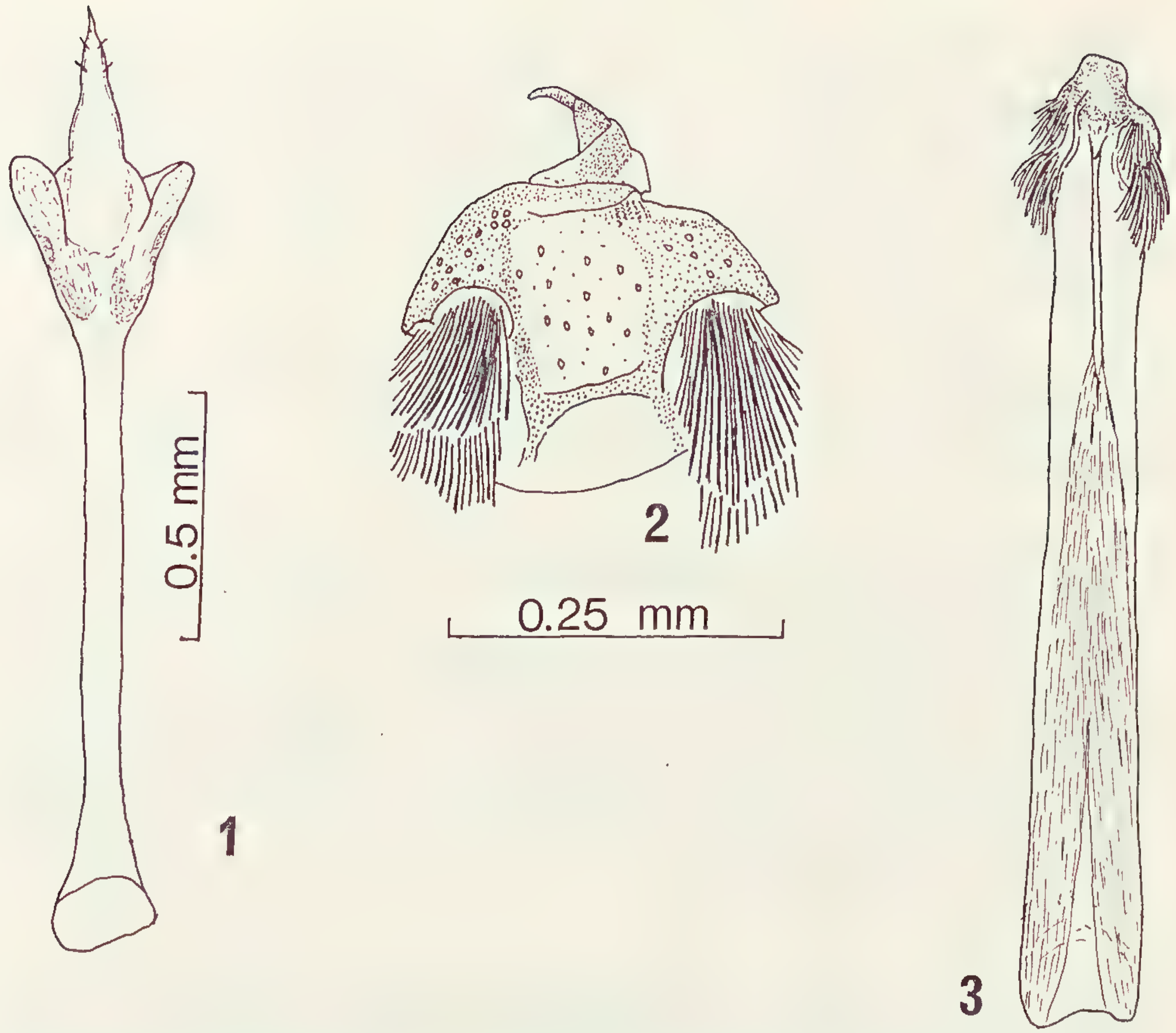
Nelima Roewer, 1910: 238.—Roewer, 1923: 910.—Martens, 1969: 395.

Nodala Forster, 1949: 70; new synonym.

Forster (1947) described *Nelima dunni*, the first Australian representative of the predominantly holarctic subfamily Leiobuninae. All specimens examined were collected in the Melbourne suburban area, Victoria. In 1949, he removed this species from the Leiobuninae and made it the type of a monotypic genus, *Nodala*, within his newly described subfamily Megalopsalinae. No clear reason was given for this transfer, and it would appear that Forster had to stretch his subfamily concept to accommodate *Nodala* alongside the quite distinctive *Megalopsalis* Roewer and *Spinicrus* Forster. Several characters clearly distinguish *Nodala:* sexual dimorphism in dorsal segmentation is strong, with males having a distinct abdominal scute; the chelicerae lack pronounced sexual dimorphism, being short in both sexes; the dentition of the cheliceral cutting edges is relatively even; and the maxillary lobes of leg 2 have a different orientation (cf. fig. 5 in Forster (1947) with figs 2, 6, and 15 in Forster (1949)). The most fundamental differences, however, are in spiracle and genital morphology. The *Nodala* abdominal spiracle is equipped with the typical phalangiid entapophysis which is lacking in *Spinicrus* and *Megalopsalis*. The penis in *Nodala* has a leiobunine form (fig. 1). In *Spinicrus* and *Megalopsalis*, however, the penis lacks subterminal accessory hairs on the glans, usually possesses two large ventrolateral pairs of bristle groups at the base of the glans (fig. 3), and has undergone torsion. This torsion, characteristic of both New Zealand and Australian Megalopsalinae, produces varying degrees of asymmetry in the distal parts of the organ, including asymmetry in size of the bristle groups, and twists the glans distally into the form of a right-handed spiral (fig. 2).

There can be no doubt that *Nodala dunni* does not belong in the Megalopsalinae. Forster was originally correct in placing *dunni* in the leiobunine genus *Nelima* and thus *Nodala* must be sunk in synonymy.

Australian and New Zealand representatives of *Nelima dunni* were compared by the authors with other species in the genus *Nelima*. *N. dunni* proves to be a junior synonym for the south European-Mediterranean species, *N. doriae* (Canestrini).



Text Figure 1. Male genitalia. Fig. 1, penis of Sydney specimen of *N. doriae*, ventral view; fig. 2, penis of *Spinicrus stewarti* Forster, ventro-apical view; fig. 3, ventral, showing internal musculature of penis shaft. Figs. 1 and 3 at same scale.

A detailed redescription of *N. doriae* is not attempted here; this should be based on larger samples from populations in both hemispheres than are available to the present study. Instead, general comparison is made between the European, Australian and New Zealand forms. In the Synonymy reference is restricted to the more important papers.

Nelima doriae (Canestrini)

Lejobunum Doriae Canestrini, 1871: 384.

Leiobunum Doriae.—Canestrini, 1872: 16.

Nelima doriae.—Roewer, 1910: 244; 1923: 913.—Brown & Sankey, 1950: 867.—Martens, 1966: 360; 1969: 398.

Nelima doriai.—Marcellino, 1970: 294.

Nelima dunni Forster, 1947: 174; new synonym.

Nodala dunni.—Forster, 1949: 70; new synonym.

External characters.—Most specimens from introduced populations show striking similarity in colour pattern to the Italian forms: male specimens show faint paired brown patches on tergal areas 1 and 2 (cf. Martens, 1969, Fig. 6). Denticulation of the body, eyemound, legs and pedipalps in general matches descriptions of *N. doriae* specimens. There is, however, wide variation in both European and introduced populations. This is particularly so for the pedipalp, notably in proximoventral denticulation of the tarsus (variation both between and within individuals). The Sydney specimens appear to have less denticulation on pedipalps than others and analysis of larger samples could show meaningful trends.

Genital morphology.—Penis (fig. 1) closely resembles that of the Jugoslavian form (cf. Martens, 1969, figs. 17, 18)*. It differs strongly from that in the Spanish and Moroccan forms (cf. Martens, figs. 19–22) where the penis shaft is more expanded basally and the basal opening almost triangular.

Metrics.—Measurements vary considerably between populations. For example, leg 1 femur length of males is plotted against scute length (midpoint anterior margin of dorsum to midpoint posterior margin of tergal area 5) on a log-log scale (fig. 4) Summary statistics for these measurements and the ratio between them are given in table 1. The sample from each locality is compared with both the Sydney and Edwardstown samples using a *t*-test of difference between the two means. In comparisons involving the Kangaroo Valley and Chioggia samples (single specimens only) the traditional *t*-test was used but with the single specimen not contributing to degrees of freedom or variance. This test was also used for femur 1 length and ratio means in comparing the Sydney and Edwardstown samples (variances not significantly different). In other comparisons, inequality of variance was assumed and the "approximate *t*-test" used.

Significant differences are indicated in Table 1. Larger samples could reveal further significant differences. The fact that three of the six specimens from Crete fall outside the 95% equal frequency ellipse for the Sydney form (in which 95% of individuals in the Sydney population would be expected to lie) is very suggestive in this regard (Fig. 4).

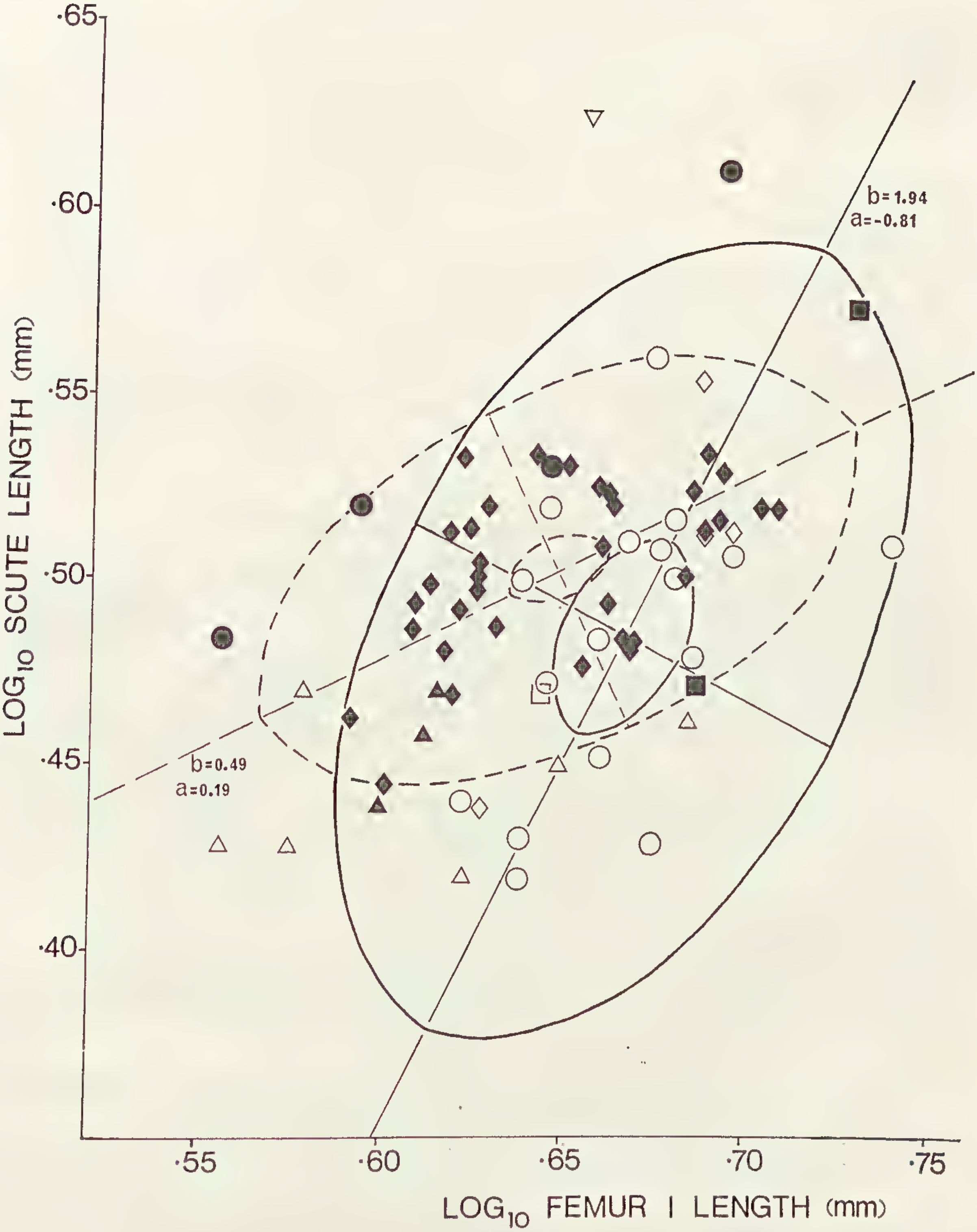
Scute length variance in the Sydney sample is significantly different ($p < 0.001$) from the Edwardstown sample, partly explaining the difference in slope of the correlation ellipse principal axes (fig. 4).

Remarks.—As our European material of *N. doriae* is limited and Martens (1969) allows considerable variation in his description of the species, general identity only can be shown between the Australian-New Zealand populations and those of the southern European-Mediterranean region. The Australian populations, however, appear to resemble the Italian-Jugoslavian ones closely and differ most strongly from the Spanish-Moroccan forms.

A detailed study of variation between the various isolated populations in this species could be of considerable interest.

---

* Figs 15, 17, 19 and 21 in Martens (1969) are of ventral surface, not dorsal as indicated in the caption.



Text-figure 2. Fig. 4. Log-log scattergram of scute length and femur length for samples from several populations of *N. doriae*. The inner and outer ellipses are respectively the 95% confidence region for the bivariate mean and the 95% equal frequency ellipse for the Edwardstown (ellipses with broken boundaries) and Sydney population samples. Slopes and *y*-intercepts of the principal axes are shown. Open circles, triangles, inverted triangle, square and diamonds represent Sydney, Crete, Kangaroo Valley, Italy and Underdale specimens; solid circles, triangles, squares and diamonds represent Melbourne, Leongatha, Dargaville and Edwardstown.

Material examined

Europe

Italy: 1♂, 1♀, Chioggia, 5–7.ix.1960, Kritscher, (Naturhistorisches Museum Wien—N.M.W.).

Greece.—Crete: 6♂, 10♀, 6 juv., Aghia Pelagia, 25.iv.1965, Paget, Kritscher & Bilek (N.M.W.).

Australia

New South Wales, Sydney: 2♂, 1♀, North Sydney, 22.i.1968, G. S. Hunt (N.M.W.); 4♂, 7♀, 8 juv., same data, author's (G.S.H.) personal collection; 2♂, 2 juv., 9.vii.1970, G. S. Hunt (G.S.H.); 4♀, 5 juv., Neutral Bay, 29.i.1968, G. S. Hunt (G.S.H.); 1♀, 2 juv., 30.i.1968, G. S. Hunt (G.S.H.); 1♀, Ryde, 12.xi.1969, H. Brammel (G.S.H.); 30♂, 4♀, 3 juv., Ermington, 11.iii.1955, P. Goodwin (Australian Museum, Sydney—A.M.); 1♀, Cammeray, summer, 1970, J. E. Mumford (G.S.H.); 1♀, Kensington, University of N.S.W., 20.ii.1971, G. S. Hunt (G.S.H.); 6♂, 10♀, 10 juv., Brighton-Le-Sands, March, 1959 Mrs. E. McLure, (A.M.); 1♀, Bexley, 16.xi.1947 (H. Hughes), (A.M.)

Kangaroo Valley (via Nowra): 1♂, half way up climb out of Valley, Fitzroy Falls Road, summer, 1971, R. Mascord (Mascord Coll., A.M.).

Victoria, Melbourne: Holotype male and allotype female of *Nelima dunni* Forster, Carnegie, 10.viii.1946, R. A. Dunn (A.M. Cat. No. K67728); paratype male of *N. dunni*, same data (National Museum of Victoria, Melbourne—N.M.); paratype male and female of *N. dunni*, same data (Dominion Museum, N.Z., Reg. Entry 2/62); Moreland, 24.v.1951, C. Wentworth (N.M.); 3♂, 8♀, 3 juv., Learmont, 13.xii.1966, A. Neboiss (N.M.); 2♂, 1♀, Hawthorn South, 22.iv.1952, J. Roff (N.M).

Leongatha: 3♂, 1 juv., 13.ix.1966, Mrs Lyndon (N.M.).

South Australia, Adelaide: 1♂, 1♀, 1 juv., 16.vi.1963; 2♀, 12.iv.1964; 2♂, 1 juv., 19.iv.1964; 2♂, 1♀, 29–30.viii.1964; 3♀, 5 juv., xii, 1964; 3♂, 3♀, 19 juv., 22.i.1965; Underdale, G. F. Gross (South Australian Museum, Adelaide—S.A.M.).

Edwardstown (near Adelaide): 35♂, 27♀, 38 juv., 4.iv.1972, D. C. Lee (S.A.M.).

Mt Gambier: 1♂, 30. vii. 1971, N. Poulter (S.A.M.).

New Zealand.—Dargaville: 2♂, 6.i.1967, R. R. Forster (Otago Museum).

Auckland: 1♀, Papatoetoe, 2.ix.1966, K. A. J. Wise (Auckland Museum).

NOTES ON BIOLOGY

Australian forms of *N. doriae* are restricted to culturally disturbed habitats. The endemic *Spinicrus* and *Megalopsalis*, however, are rarely found in these habitats, and then mostly in moist sheltered situations adjacent to natural bush.

N. doriae seems widespread in Sydney and Melbourne. A favoured habitat is behind grass growing against walls and fences, frequently in open situations exposed to the sun for much of the day. Individuals are often found in buildings, expecially damp garages and sheds, with bodies and legs pressed tightly against the walls. They are sometimes found in houses, especially early in the morning.

In Sydney, adults and juveniles can be collected throughout winter but, as in most phalangiids, there is an increase in numbers during spring and early summer and a decrease in autumn and winter. More than one generation per year probably occur and this may in part explain the success of this species in unstable urban environments (cf. *Phalangium opilio*, Clingenpeel and Edgar (1966)).

DISTRIBUTION OF *NELIMA DORIAE*

A distribution map for the primary (European) range is given by Martens (1969) but does not include recent records in Sicily (Marcellino, 1970). Although knowledge of this distribution is incomplete, most populations occur in Italy and Jugoslavia with outliers in Caucasia (*N. pisarskii* of Staręga, 1966), Spain and Morocco. The species is believed to have been introduced to Crete (Martens, 1969).

Occurrences in Australia and New Zealand are secondary. The time and method of introduction are not known. Judging from Dunn's (1946) remarks, the species was well established in Melbourne by that year. The earliest record for Sydney is 1947. Introduction to New Zealand appears to have been more recent, and probably via Australia. The species is now well established in the Auckland district (R. R. Forster, pers. comm.).

The species does not appear to have been introduced to Brisbane (B. Cantrell, pers. comm.), Perth and Hobart.

KNOWN INTRODUCTIONS OF HARVESTMEN

There are numerous reports inferring the introduction of harvestmen from one country to another by human agency. Some of these may be suspect due to misidentification or false locality records. As usual, marked separation from the normal distribution of the species together with ecological data, especially an association with man or culturally disturbed habitats, may be taken as evidence for secondary range extensions. Most cases concern species of the north-temperate zone, transport either occurring within the zone or across the tropics with subsequent invasion of the south-temperate zone.

The majority involved are long-legged epigean species belonging to the family Phalangiidae (suborder Palpatores), especially the subfamily Phalangiinae (table 2). There are only two known introductions of short-legged cryptozoic species (listed at bottom of table 2), including the only representative from the suborder Laniatores.

Apart from *N. doriae*, two species of harvestmen are known to have been introduced to the Australian-New Zealand region: *Opilio parietinus* in Tasmania (Hickman, 1957) and *Phalangium opilio* in New Zealand (Forster, 1962; Forster and Forster, 1970). Both are found in disturbed habitats and have not been collected in natural bush.

ACKNOWLEDGMENTS

We wish to thank the Directors of several museums for loan of material, especially Dr R. R. Forster, Otago Museum, for drawing our attention to the existence of *N. doriae* in New Zealand. We are grateful to Mr D. C. Lee, Curator of Arachnids and Crustacea, South Australian Museum, who made a special collection of South Australian material.

We also wish to thank Dr A. M. Richards, School of Zoology, University of New South Wales, for criticising the manuscript, and Mr M. R. B. Gray, Assistant Curator (Arachnology) at the Australian Museum, for assistance during research at the Museum.

REFERENCES

Balazuc, J., 1962. Troglobie des cavités artificielles. *Spelunca, Mém.* 2: 104–107.

Brown, D. G. and Sankey, J. H. P., 1950. The harvest-spider *Nelima silvatica* (Simon) in Great Britain. *Proc. zool. Soc. Lond.* 119 (4): 867–871.

Canestrini, G., 1871. Nuove specie di Opilionidi italiani. *Boll. Soc. ent. Ital.* 3: 381–385.

——— 1872. Gli Opilionidi italiani. *Annali Mus. civ. Stor. nat. Giacomo Doria* 2: 5–48.

Clingenpeel, L. W. and Edgar, A. L., 1966. Certain ecological aspects of *Phalangium opilio* (Arthropoda: Opiliones). *Pap. Mich. Acad. Sci.* 51: 119–126.

Dunn, R. A., 1946. Notes on Australian harvestmen. *Vict. Nat.*, 68 (7): 165–166.

Forster, R. R., 1947. A new harvestman of the subfamily Liobuninae from Australia. *Mem. natn. Mus. Vict.* (15): 174–177.

——— 1949. Australian Opiliones. *Mem. natn. Mus. Vict.* (16): 59–89.

——— 1962. A key to the New Zealand harvestmen—Part 1. *Tuatara* 10 (3): 129–137.

Forster, R. R. & Forster, L. M., 1970. *Small Land Animals of New Zealand.* John McIndoe, Dunedin. Pp. 175.

Gruber, J., 1964. Kritische und ergänzende Beobachtungen zur Opilioniden-fauna Österreichs (Arachniden). *Z. ArbGem. Öst. Ent.* 16 (1/3): 1–5.

Hackman, W., 1956. Phalangida (Opiliones) from Newfoundland. *Commentat. biol.* 15 (17): 1–9.

Hickman, V. V., 1957. Some Tasmanian harvestmen of the sub-order Palpatores. *Pap. Proc. R. Soc. Tasm.* 91: 65–79.

Kauri, H., 1963. Harvestmen (Opiliones) from the Azores (Report No. 27 from the Lund University Expedition to Madeira and the Azores in 1957). *Bolm Mus. munic. Funchal*, (15): 10–18.

Lawrence, R. F., 1959. Arachnides Opilions. *Faune Madagascar* 9: 1–121.

Marcellino, I., 1970. Su alcuni Opilioni (Arachnida) della Sicilia sud-orientale e centrale. *Boll. Sed. Accad. gioenia Sci. nat.* (IV), 10 (4): 283–308.

Martens, J., 1966. Zoologische Aufsammlungen auf Kreta. III. Opiliones. *Annln naturh. Mus. Wien* 69: 347–362.

——— 1969. Mittel- und südeuropäische Arten der Gattung *Nelima* (Arachnida: Opiliones: Leiobunidae). *Senckenberg. biol.* 50 (5/6): 395–415.

Muchmore, W. B., 1963. Two European arachnids new to the United States. *Ent. News*, 74 (8): 208–210.

Roewer, C. Fr., 1910. Revision der Opiliones Plagiostethi (=Opiliones Palpatores). 1. Teil: Familie der Phalangiidae (Subfamilien: Gagrellini, Liobunini, Leptobunini). *Abh. Geb. Naturw., Hamburg*, 19 (4): 1–294.

——— 1923. *Die Weberknechte der Erde.* G. Fischer, Jena. Pp. 1116.

Sankey, J. H. P. & Storey, M. W., 1969. *Dicranopalpus caudatus* Dresco (Arachnida, Opiliones), first records in Britain and France. *Entomologists' mon. Mag.*, 105: 106–107.

Spoek, G. L., 1963. The Opilionida (Arachnida) of the Netherlands. *Zool. Verh., Leiden* 63: 3–70.

Staręga, W., 1966. Beitrag zur Kenntnis der Weberknecht-Fauna (Opiliones) der Kaukasus-Länder. *Annls zool., Warsz.* 23 (13): 387–411.

——— 1967. Einige Weberknecht-Arten (Opiliones) aus Israel. *Israel J. Zool.* 15, 1966: 57–63.

Table 1

Summary Statistics for Scute and Femur 1

Measurements for Males of *N. doriae*

		Sydney (N.S.W.)	Kangaroo Valley (N.S.W.)	Leongatha (Vic.)	Melbourne (Vic.)	Edwardstown (S.A.)	Underdale (S.A.)	Dargaville (N.Z.)	Aghia Pelagia (Crete)	Chioggia (Italy)
Sample size	n	17	1	3	4	35	4	2	6	1
Scute length (mm)	Significance		*** +++						+	
	$\bar{x}$	3.066	4.22	2.857	3.455	3.183	3.213	3.340	2.777	2.95
	s^2	0.074	. .	0.010	0.189	0.026	0.120	0.304	0.017	. .
	Range	2.63–3.64	. .	2.75–2.95	3.05–4.07	2.78–3.41	2.75–3.59	2.95–3.73	2.63–2.95	. .
Femur 1 length (mm)	do			*						
		4.650	4.53	4.067	4.228	4.468	4.753	5.140	4.090	4.40
		0.096	. .	0.006	0.348	0.111	0.114	0.135	0.200	. .
		4.20–5.52	. .	3.98–4.13	3.60–4.95	3.92–5.13	4.25–4.98	4.88–5.40	3.60–4.73	. .
Ratio of scute to Femur 1 length	do	+++	*** +++		* +	***				
		0.661	0.932	0.700	0.820	0.715	0.675	0.645	0.683	0.670
		0.003	. .	0.0001	0.001	0.002	0.002	0.004	0.005	. .
		0.57–0.77	. .	0.69–0.71	0.77–0.85	0.64–0.81	0.65–0.74	0.60–0.69	0.61–0.78	. .

Significance of difference between mean and mean of Sydney sample or mean of Edwardstown sample:
* or +, $0.05 > p > 0.01$; *** or +++, $0.001 > p$

Correlation coefficients between scute and femur 1 length in Sydney and Edwardstown samples are respectively, 0.453 and 0.492.

Table 2

Known Introductions of Harvestmen (World Survey)

Species	Place(s) of Introduction	Adopted Habitat	Possible Place of Origin (and Nature of Habitat)	References
Suborder Palpatores Fam. Phalangiidae Subfam. Phalangiinae				
Opilio parietinus (DeGeer)	Wide holarctic distribution possibly due to transport by man. Tasmania.	Common on walls, fences and hedges.	Western Asia—Anatolia, Caucasia (under rocks and on tree trunks, rocks and shrubs).	Spoek (1963) Staręga (1966). Hickman (1957).
O. saxatilis C.L.K.	Israel.	Disturbed habitats.	Europe (field layer near ground, common in grass of coastal dunes).	Spoek (1963). Staręga (1967).
O. ruzizkai Šilhavý	Vienna district, Austria.	Lower vegetation and tree trunks in parks and woods.	South-east Europe.	Gruber (1964).
Phalangium opilio L.	Wide holarctic distribution possibly due to transport by man. New Zealand.	Fields, other open grassy areas, gardens.	Europe? (grass-lands, open habitats).	Spoek (1963). Hackman (1956). Clingenpeel and Edgar (1966). Forster (1962). Forster and Forster (1970).
Dicranopalpus caudatus Dresco	Hove and Bournemouth, southern England.	Privet and other bushes.	Iberian peninsula (generally low vegetation).	Sankey and Storey (1969).
Subfam. Leiobuninae *Nelima doriae* (Canestrini)	See text.			
Subfam. Sclerosomatinae *Homalenotus coriaceus* Simon	São Miguel (Azores)	Variety of habitats, disturbed and undisturbed.	Southern France, Iberian peninsula, Morocco (variety of exposed and even very dry habitats).	Kauri (1963).
Subfam. Gagrellinae *Strandia ceylonensis* (Karsch)	Mauritius and Reunion.	Littoral vegetation only.	Indian region.	Lawrence (1959).
Family Trogulidae *Trogulus tricarinatus* (L.)	Near Rochester, New York State.	Under logs in deciduous woodland.	Europe (leaf litter, under stones, etc., especially on calcareous soils).	Muchmore (1963).
Suborder Laniatores Family Phalangodidae *Scotolemon terricola* Simon	Catacombes de Chaillot (Paris).	Artificial caves.	Corsica.	Balazuc (1962).

NATIONAL MUSEUM
16 JUL 1973
OF VICTORIA

The Harpacticoid Copepods (Crustacea) of the Saline Lakes in Southeast Australia, with Special Reference to the Laophontidae

By R. Hamond

CSIRO, Division of Fisheries and Oceanography, Cronulla, N.S.W., Australia

Figures 1–81. Manuscript received, 28th March, 1972

SUMMARY

The bottom-living copepods collected by Dr I. A. E. Bayly in the saline lakes include the cyclopoid *Halicyclops ambiguus* Kiefer and six species of harpacticoid, namely *Mesochra baylyi* Hamond, *Onychocamptus bengalensis* (Sewell), *Cletocamptus deitersi* (Richard), *Heterolaophonte wellsi* sp. nov., *Robertsonia propinqua* (Scott), and an undescribed species of *Amphiascoides*. *M. baylyi* was by far the most widespread and numerous harpacticoid, and in many of the samples it was the only harpacticoid present. *O. bengalensis* was the second most numerous and widespread harpacticoid, the other harpacticoids all being scarce; *H. ambiguus* was about as common as *O. bengalensis*, and had a substantially similar distribution. *R. propinqua*, *O. bengalensis*, and *C. deitersi* are new records for Australia. *H. wellsi* has been found only in high-salinity localities lacking weeds, and therefore appears to favour the bottom sediments; none of the other species showed any distinct preference for localities with or without weeds. The present paper also contains the description of *H. wellsi*, a redescription of *O. bengalensis*, and notes on *C. deitersi*.

INTRODUCTION

As has been shown by Bayly (1970) and by Bayly and Williams (1966), the saline lakes in question contain an interesting fauna, characterised by the widespread occurrence throughout the lake system of a limited number of species, most of which are of marine origin; this is clearly true of the bottom-living copepods (Table 2), which consisted of the cyclopoid *Halicyclops ambiguus* Kiefer (1967) and of a mere six species of harpacticoid. The synonymy of previous records is as follows:

Bayly and Williams (1966), Table 14	Bayly (1970), pp. 124–125	Present name and reference
Mesochra sp.	*Mesochra* sp. nov.	*Mesochra baylyi* Hamond (1971)
Onychocamptus sp.	*O. bengalensis* (Sewell)	*O. bengalensis* (Sewell), redescribed below
Robertsonia cf. *R. knoxi*	*Robertsonia* sp. nov.	*R. propinqua* (T. Scott), see Hamond (in press)
Halicyclops, sp. nov.	*H. ambiguus*	*H. ambiguus*, see Table 2 of present paper
....	*Heterolaophonte* sp. nov.	*H. wellsi* sp. nov., described below
....	....	*Amphiascoides* sp. nov., to be described elsewhere
....	....	*Cletocamptus deitersi* (Richard), partly redescribed below

MATERIAL AND METHODS

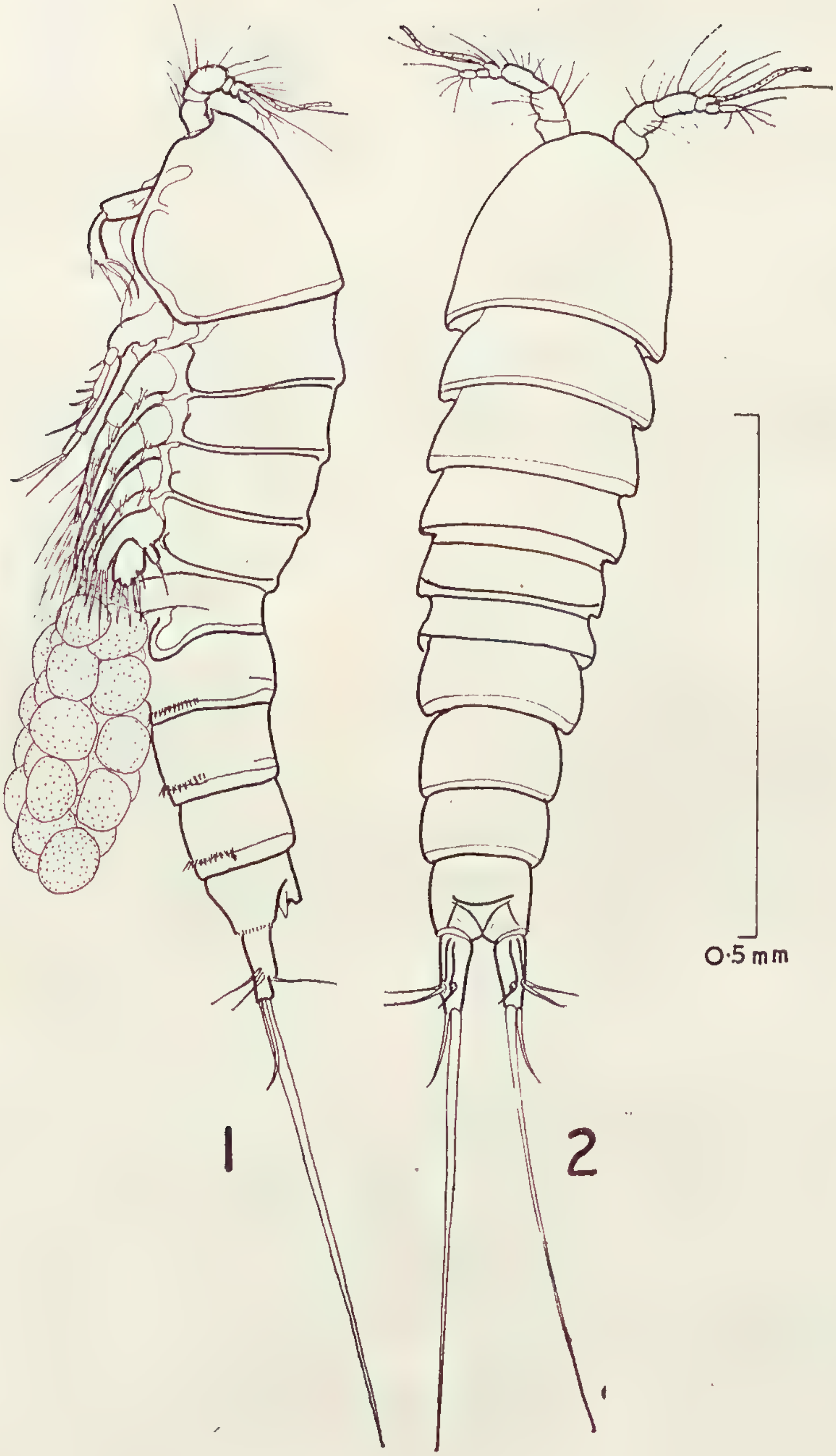
Each sample listed in Table 2 consisted of a single tube, in which the cleaned copepods were preserved in dilute formalin; the standard of preservation was generally high. The samples were not quantitative in any ecological sense; repeat samples were taken in some localities (e.g. locality 13) on different dates. Not included in Table 2 is a lagoon (near the head of The Coorong, some 46 miles north of Kingston in South Australia), a sample from which on 22.5.1968 (salinity 16.2%) yielded nineteen females (of which eight were ovigerous), no males, and no copepodites of *Mesochra baylyi;* in Table 2 this would have been expressed as $\begin{matrix}19,8,\\0,0.\end{matrix}$. The asterisks in Table 2 (*M. baylyi* at 10B; *O. bengalensis* at 12) indicate that the number for each sample includes a pair in precopula. The copepods were studied as in Hamond (1969, 1971); holotype material has been deposited in the Australian Museum; other material is being retained in my own collection, for comparison with material to be studied in the future.

TAXONOMY

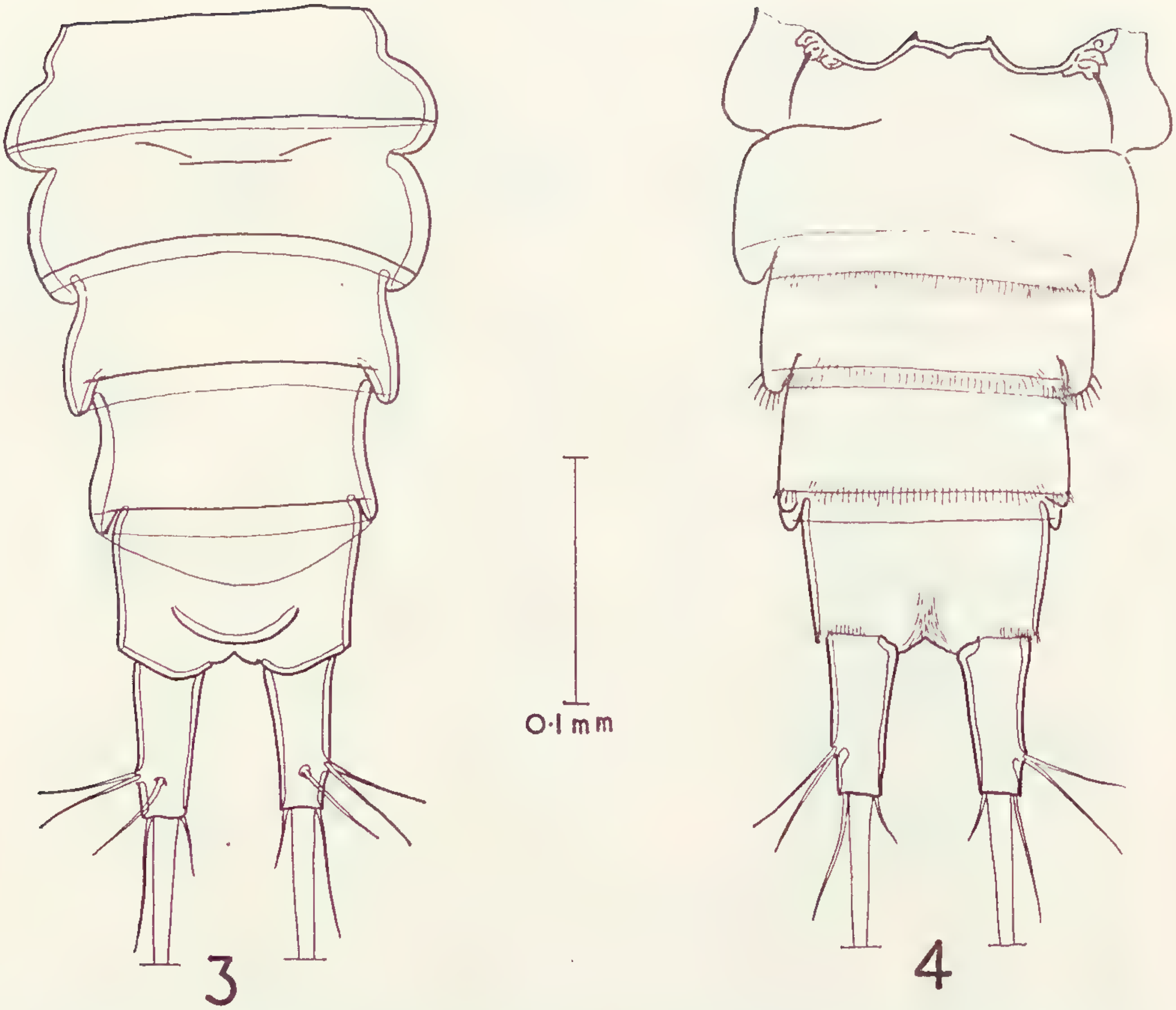
Description of **Heterolaophonte wellsi** sp. nov.

(Figs 1–26).

Female (*holotype*). General appearance very much like that of most other laophontids, without compression, flattening, or unusual protuberances. Each abdominal somite (fig. 4) has a ventrally complete row of very delicate teeth, and a lateral comb of small spinules. Dorsal sensillae not noticed in spite of searching under high power.



Figs 1, 2. *Heterolaophonte wellsi*, ♀. Fig. 1, side view; fig. 2, dorsal view.



Figs 3, 4. *Heterolaophonte wellsi*, ♀, abdomen. Fig. 3, dorsal view; fig. 4, ventral view.

Operculum smooth-edged and curved (figs 3, 5); the ridges, running from each end of the operculum to the base of each furcal ramus, have a pattern of minute chitinous roughnesses along their crests. Furcal ramus tapering slightly (ratio of length to greatest breadth about 8:3 in dorsal view), and with a pronounced dorsal carina from the base of the ramus to the insertion of the dorsal seta. There are two outer lateral setae arising together, a dorsal seta arising level with them, and three terminal setae of which only the middle one is substantially longer than the furcal ramus; this large seta is not modified in any way.

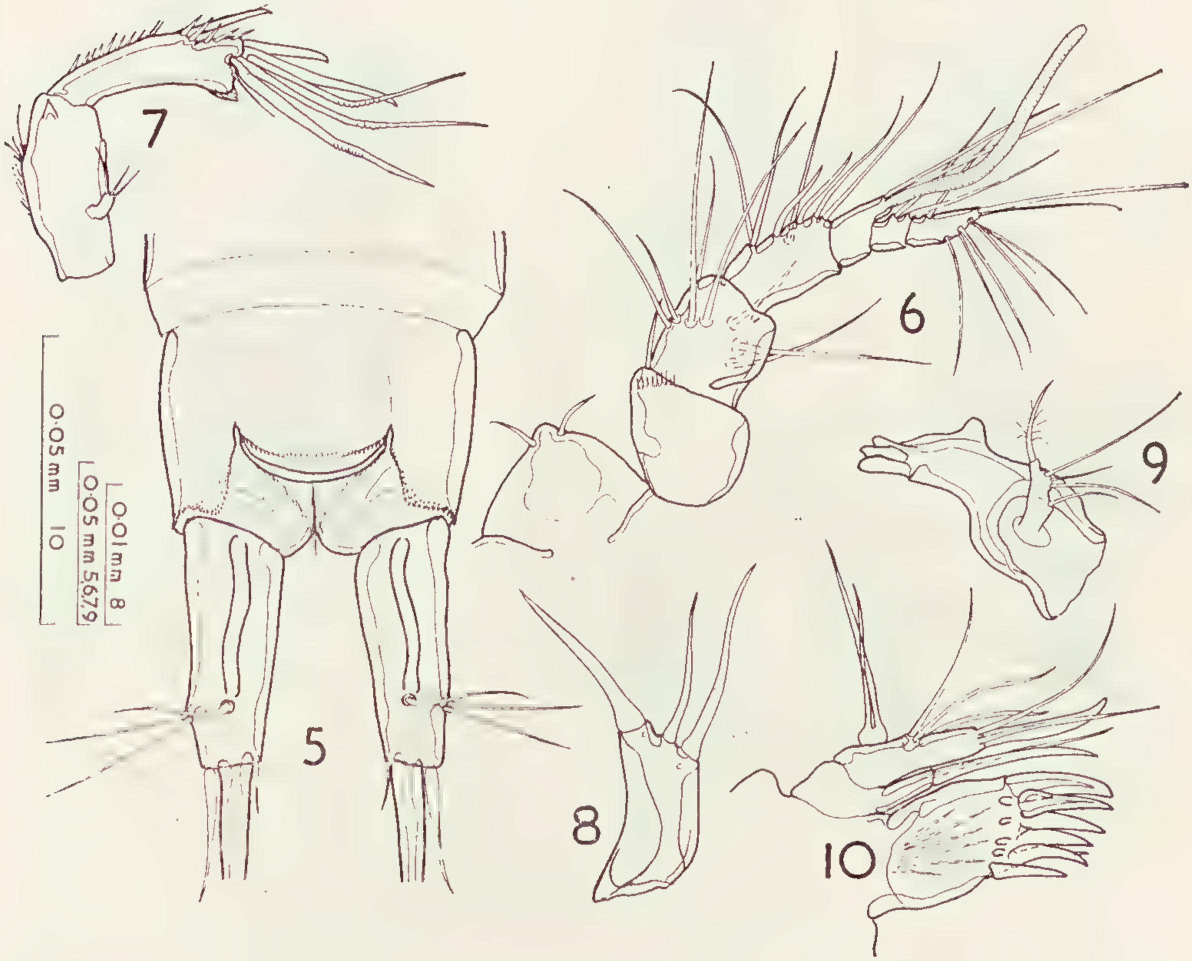
Antennule (fig. 6) with six segments, of which the fourth bears the aesthetasc; all antennular setae are smooth and simple. Antenna (fig. 7) with a single-segmented exopod (magnified in fig. 8), and with a terminal group of appendices comprising a simple seta, three kinked setae, and two hooked spines; a third hooked spine arises subterminally. Mandible (Fig. 9) with a single-segmented exopod bearing five setae, of which only the terminal is plumose. Maxillules (fig. 10), maxillae (fig. 11), and maxillipedes (fig. 12) not remarkable.

P1 (fig. 13) with a two-segmented exopod, the second segment being much the longer. The endopod is much longer than the exopod, and bears terminally a very slender and almost entirely straight claw, adaxially to which is a long slim seta and a minute terminal setule (present in all three dissected females) which may or may not represent the small seta (of which there is otherwise no trace) found in this position in many laophontids.

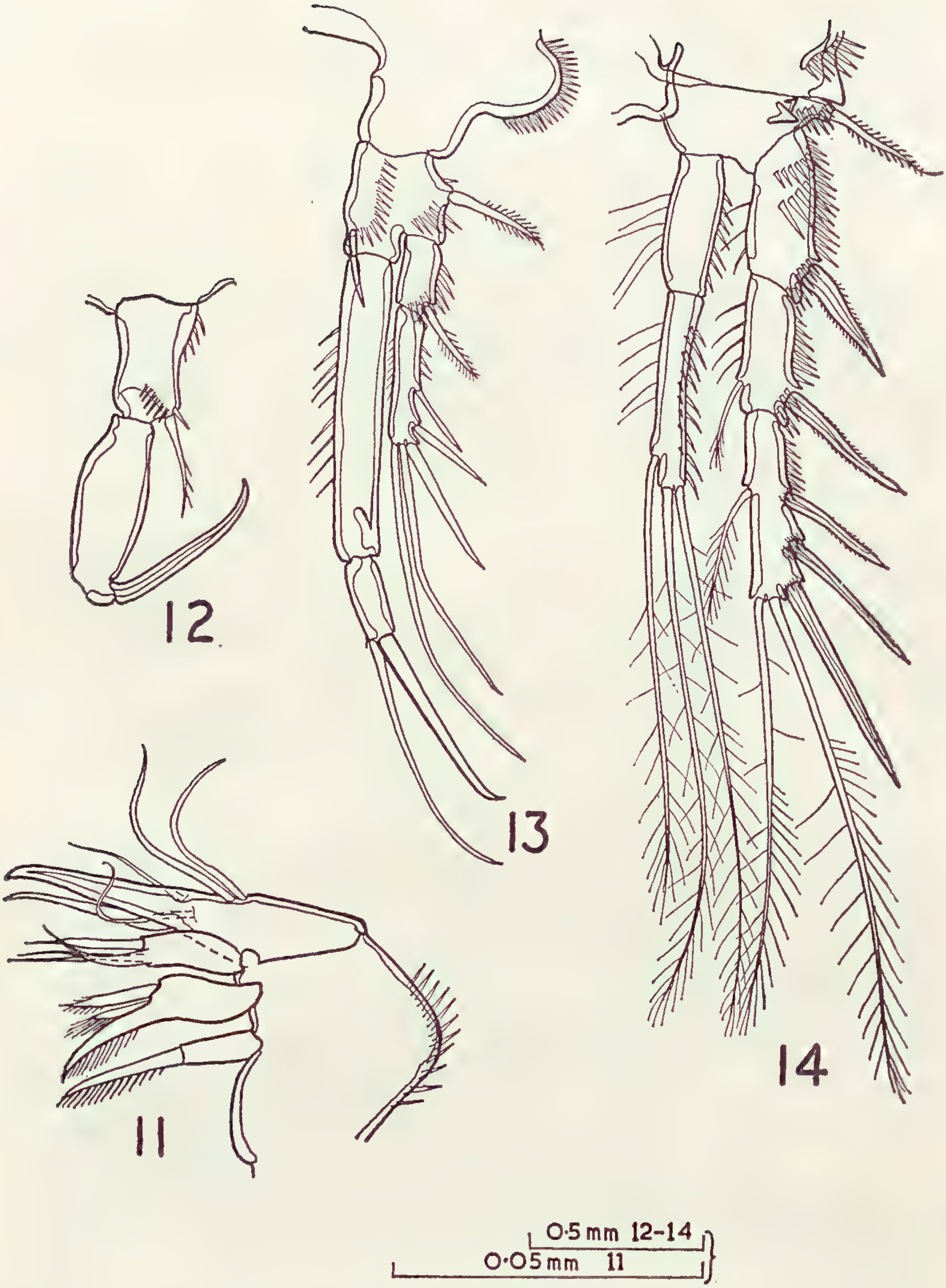
Swimming legs with three-segmented exopods and two-segmented endopods; setal formula:

P2(fig. 14)		P3(fig. 15)		P4(fig. 16)	
exp	enp	exp	enp	exp	enp
0.1.123	0.120	0.1.223	0.221	0.1.123	0.120

P5 (fig. 17) with discrete rami, the exopod not quite as long as the basiendopod; the latter bears two stout unilaterally pinnate setae on its inner margin and three plumose setae terminally, whereas the six exopodal setae are all plumose, the indentations between their bases being deeply marked.

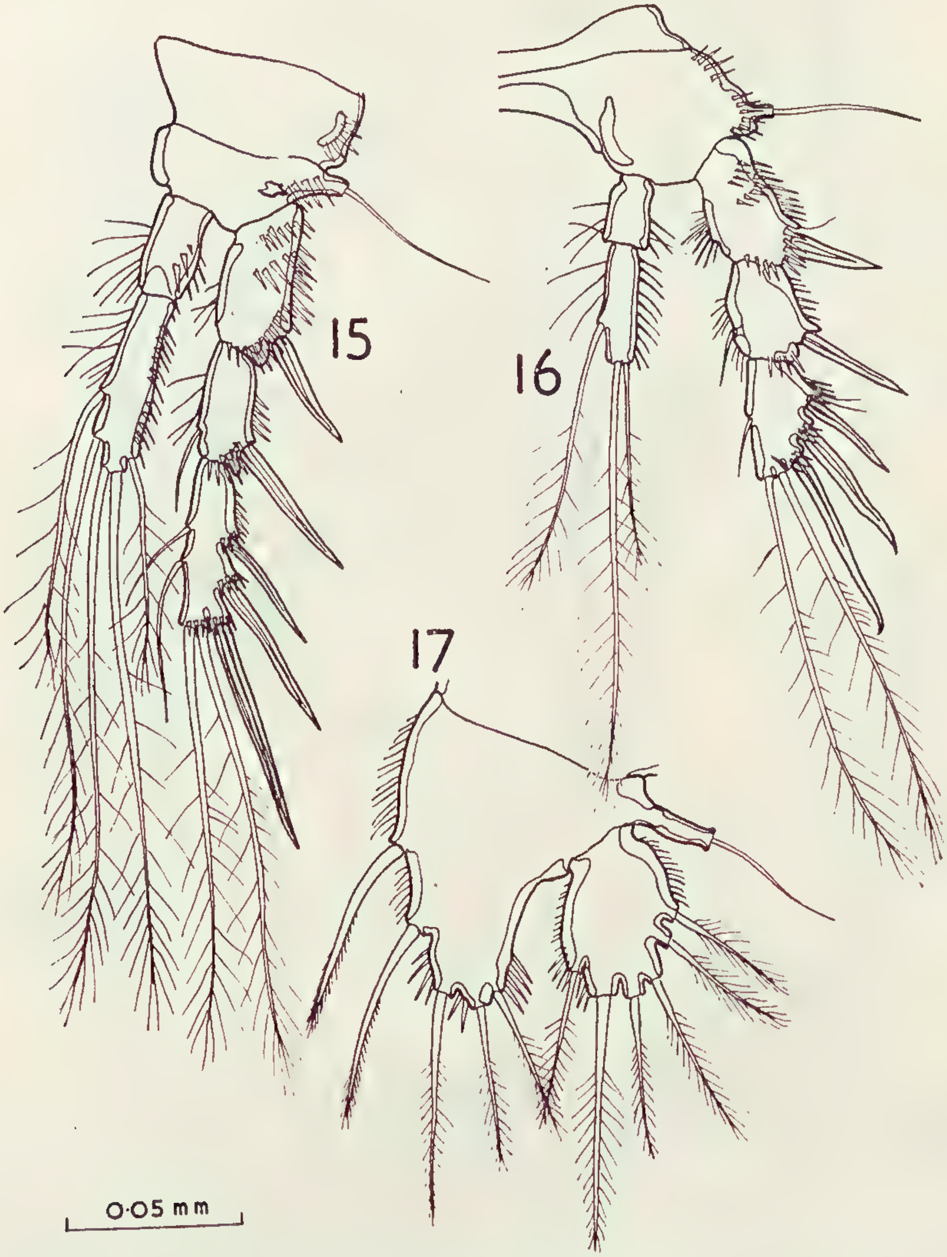


Figs 5–10. *Heterolaophonte wellsi*, ♀. Fig. 5, operculum and furca; fig. 6, R + A1; fig. 7, A2; fig. 8, A2exp; fig. 9, Md; fig. 10, Mxl.

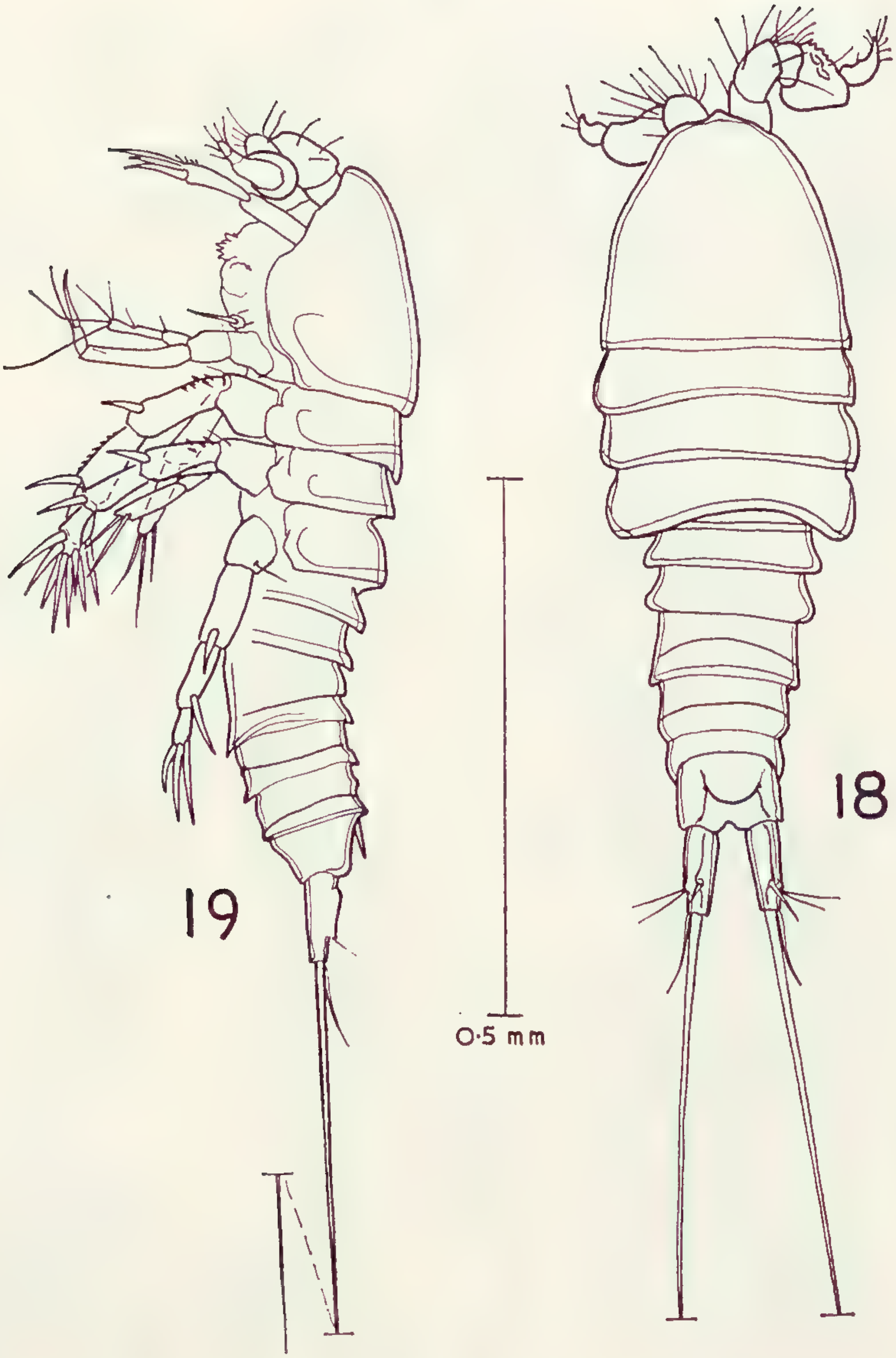


Figs 11–14. *Heterolaophonte wellsi*, ♀. Fig. 11, Mx; fig. 12, Mxp; fig. 13, P1; fig. 14, P2.

Male allotype (figs 18–26). Abdomen ornamented as in the female, but decidedly slimmer in proportion to the rest of the body (figs 18, 19). Antennule (fig. 20) with about six very indistinct segments, of which the fourth bears the aesthetasc. Antenna (fig. 21) as in the female, but bearing two subterminal hooked spines, instead of only one such spine as in all four females examined. Swimming legs showing the usual sexual dimorphism; endopods decreasing in length progressively from P2 to P4, but each of them with two segments. Setal formula as in the female, except that, on one side, P2exp3 has four outer spines (fig. 24; abnormal), and P3exp3 has a possible second inner seta (below that shown in Figure 25, but on the other leg of this pair).



Figs 15–17. *Heterolaophonte wellsi*, ♀. Fig. 15, P3; fig. 16, P4; fig. 17, P5.



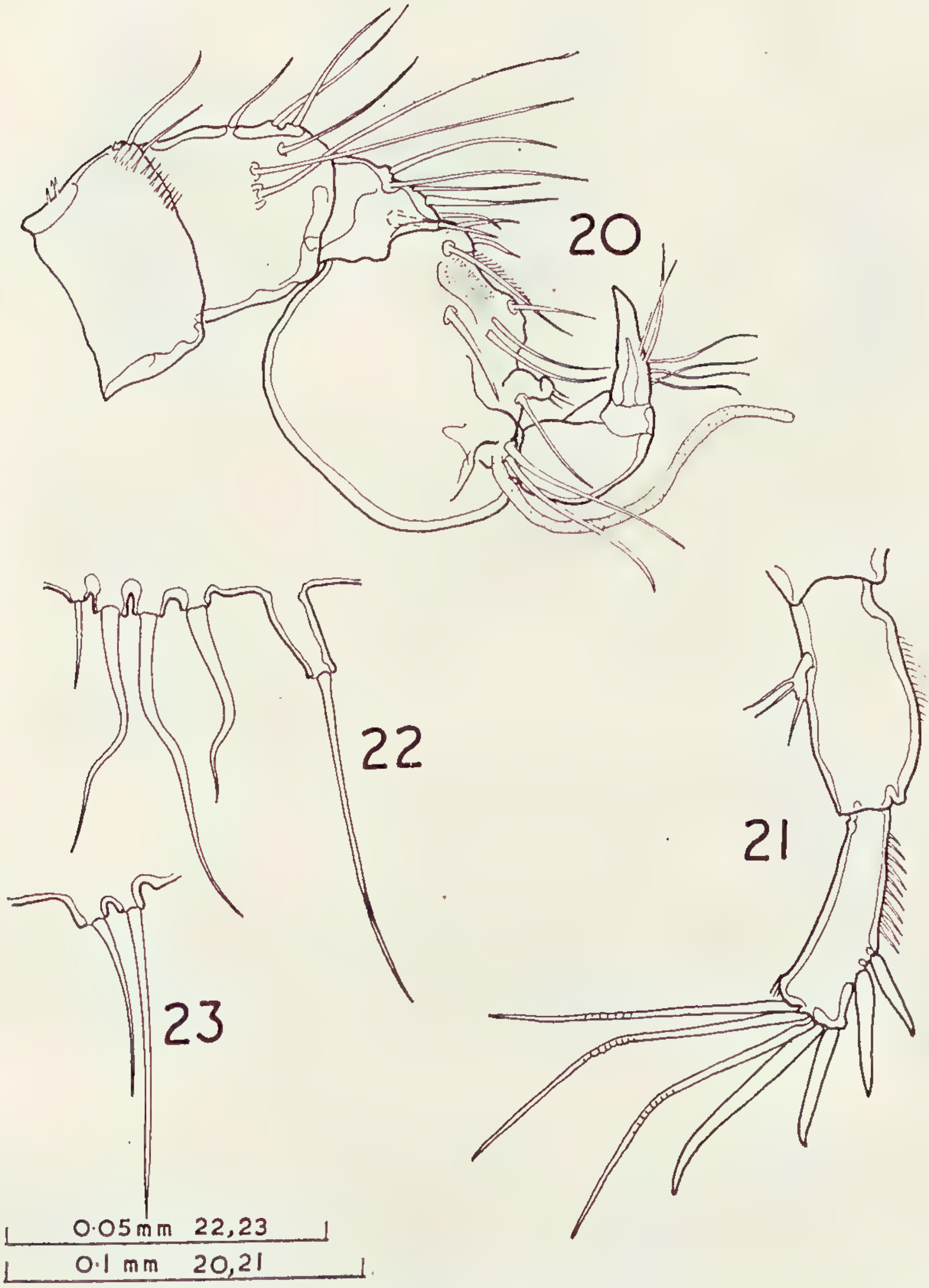
Figs 18, 19. *Heterolaophonte wellsi*, ♂. Fig. 18, dorsal view; fig. 19, side view.

This possible second inner seta is concealed behind the inner margin of the segment bearing it, but there is a distinct break in the chitin exactly where it appears to originate. The formula for P3enp2 might equally well be 320 or 221; having only one other male, I am unwilling to dissect it until more males have been found.

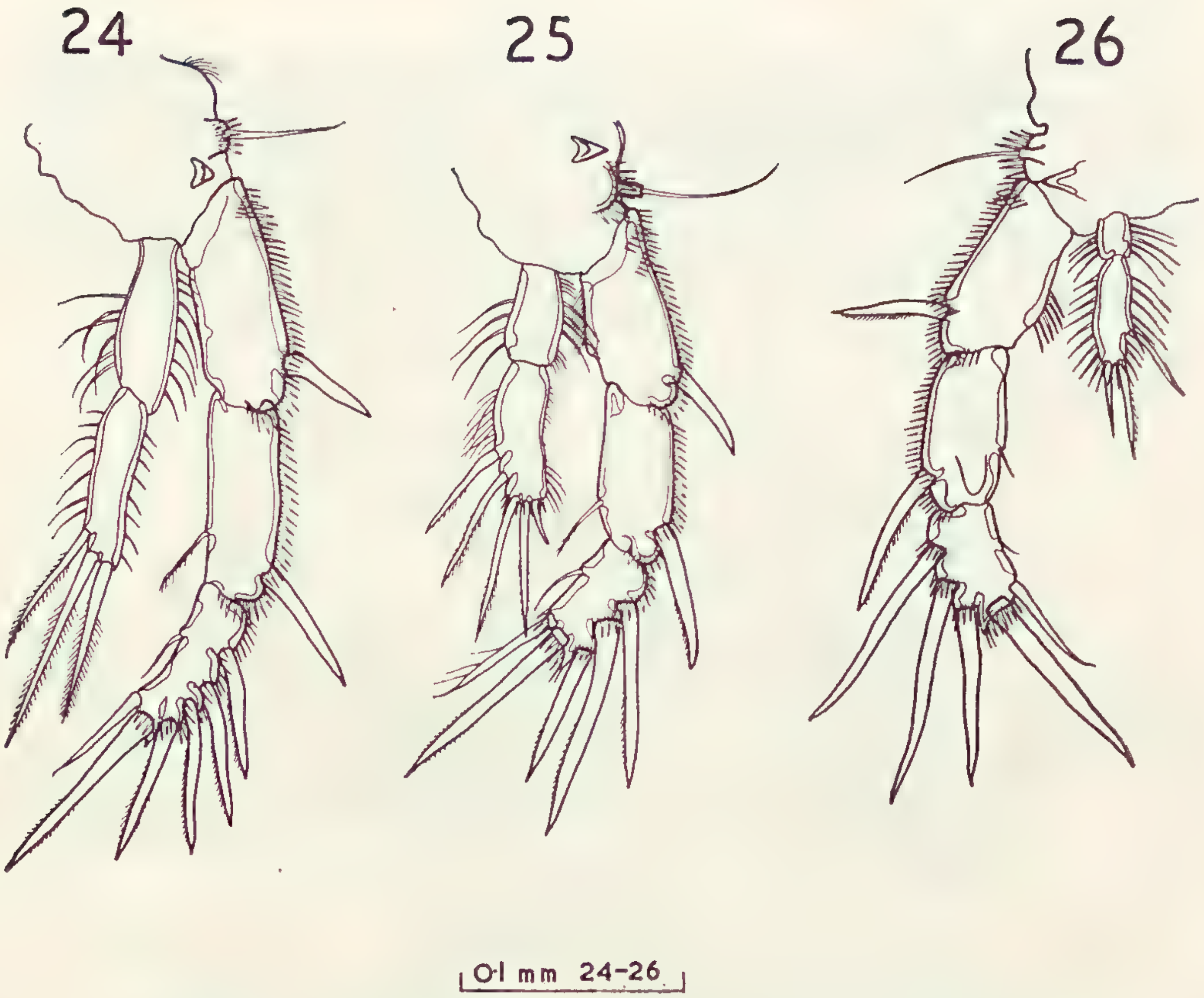
P5 (fig. 22) with four setae, all of which are smooth and rather limp; P6 (fig. 23) with two smooth setae, the outer being the longer.

Variability

The following specimens have been dissected; the holotype, a female paratype, and a copepodite, all from locality 10, and the male allotype and a second female paratype from locality 16B. The only variations found were, that in the first paratype the lefthand endopod of P4 had the formula 0.220, and that in the second paratype both exopods of P4 had the formula 0.0.123. Paratype 2 was 0.82 mm long, the other females (including those not dissected) ranging from 0.7 to 0.8 mm in length, and the copepodites from 0.45 to 0.6 mm in length. Length of holotype 0.82 mm, of allotype 0.67 mm.



Figs 20–23. *Heterolaophonte wellsi*, ♂. Fig. 20, A1; fig. 21, A2; fig. 22, P5; fig. 23, P6.



Figs 24–26. *Heterolaophonte wellsi*, ♂. Fig. 24, P2; fig. 25, P3; fig. 26, P4.

Remarks

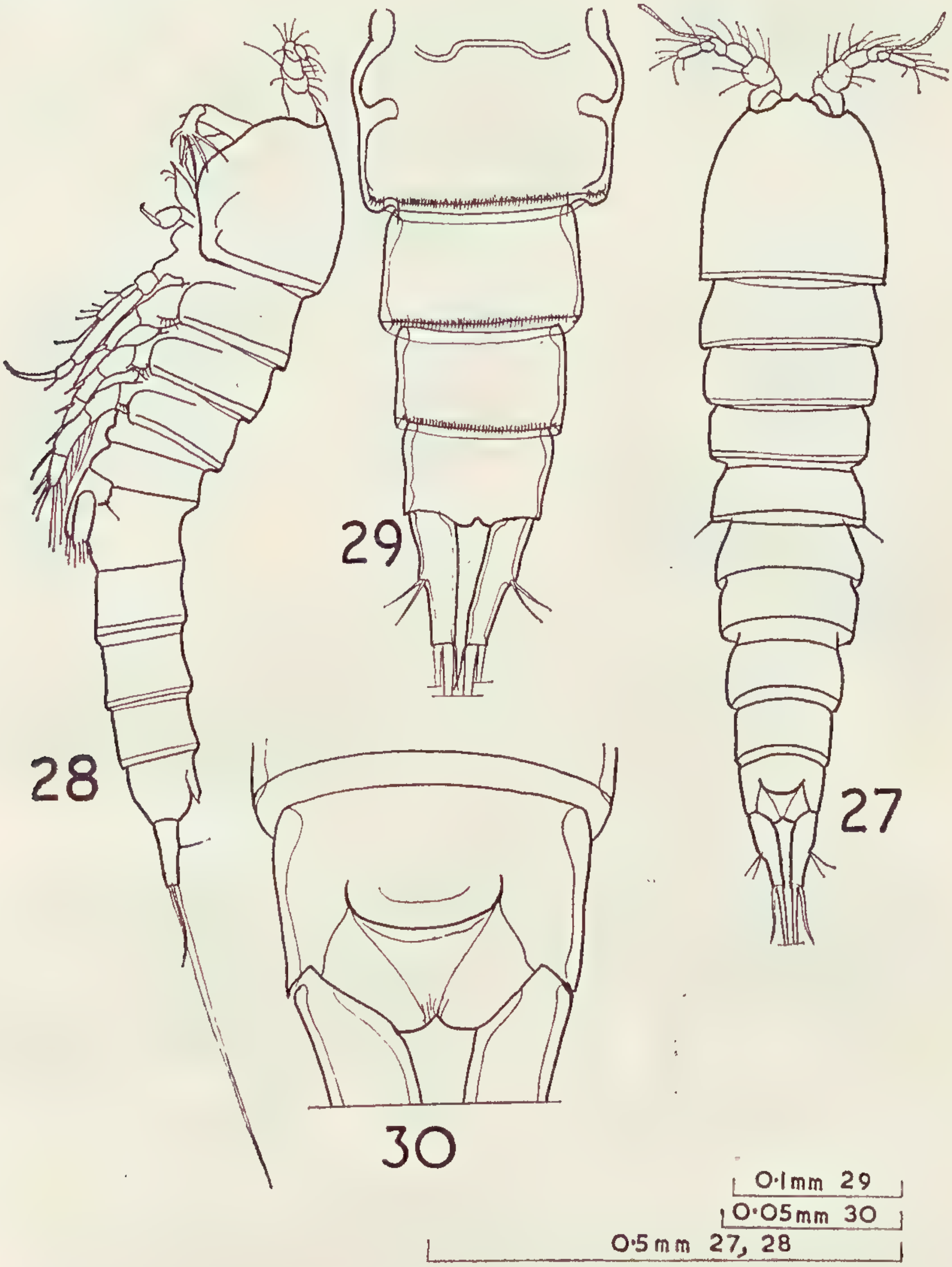
Although P1 is very like that of *Normanella*, all other features of the present species combine to place it unequivocally in the *quinquespinosa*-group of *Heterolaophonte;* the diagnosis of this group (Lang, 1948, p. 1365) does not require emendation, but a revised key to it is given below.

Ecology

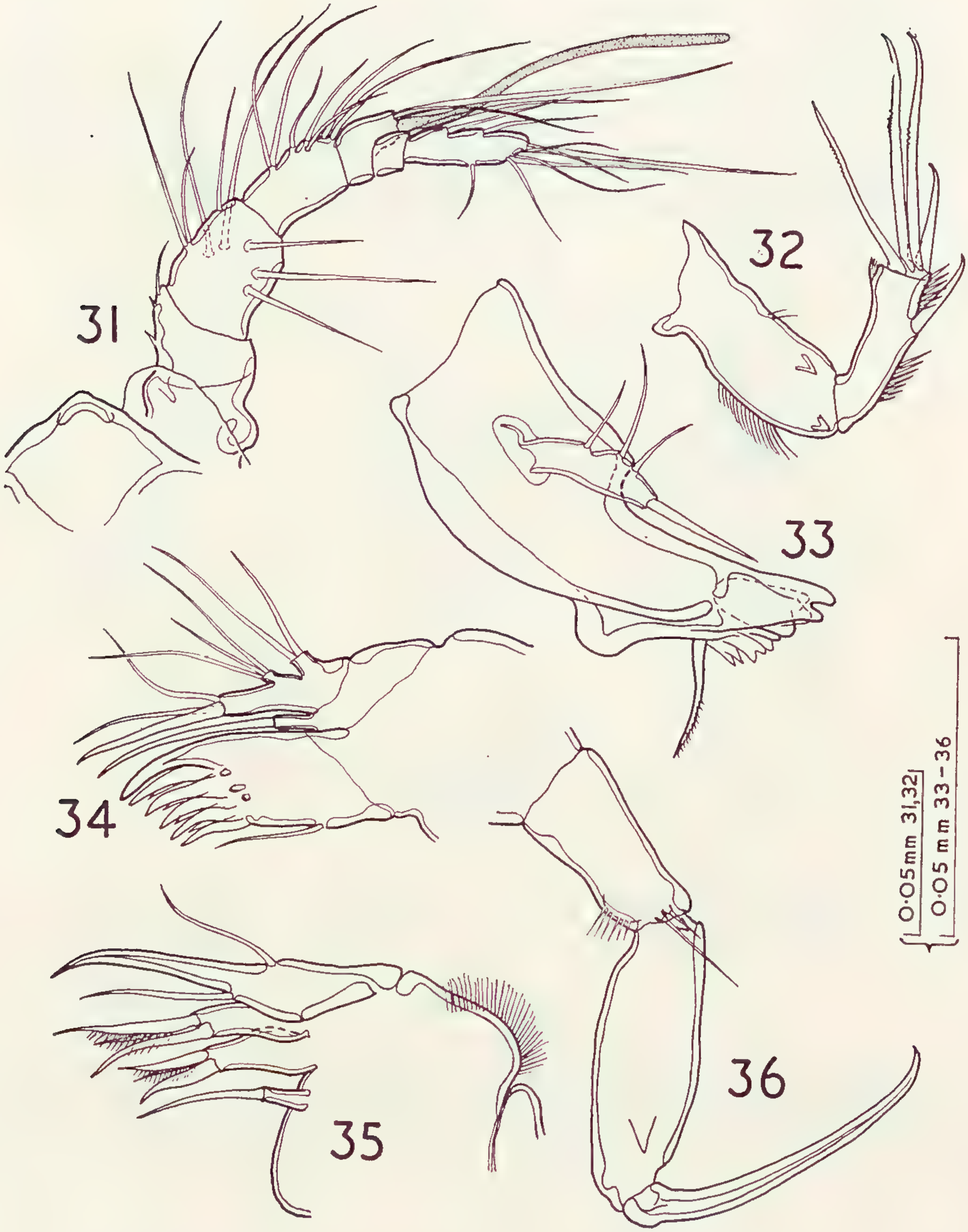
This species appears to prefer bottom sediments rather than algae (see ecology section, below); it is most unusual for a species of *Heterolaophonte* to be found in saline lakes that have been separated from the sea for perhaps centuries, although several other species which are basically marine can stand short periods of lowered or variable salinity in estuaries or tidepools (Lang, 1948).

Heterolaophonte quinquespinosa (Sewell)

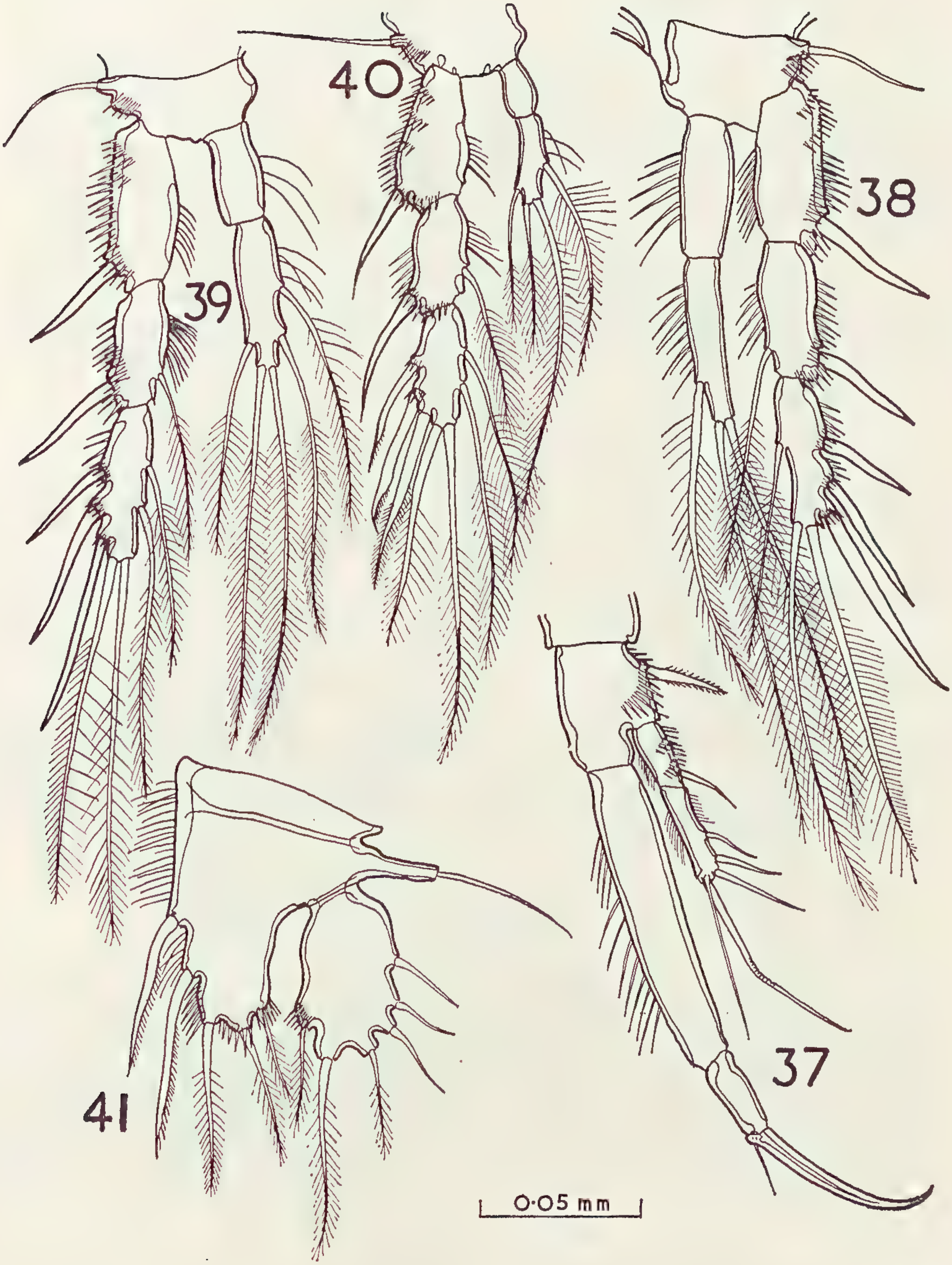
Dr J. B. J. Wells (unpublished) has come to the conclusion that this is a senior synonym of *H. sigmoides* (Willey); he kindly sent me the female studied here (figs 27–41), which was sent to him by Dr Bodin from Marseilles (Bodin, 1964, p. 151, as *H. sigmoides*). He also sent me two specimens of his own (Wells, 1963, p.24, as *H. sigmoides*), but unfortunately these were both mounted whole on slides, and the overlapping of the limbs made it impossible to see the setal formula and associated details; however, in general appearance these specimens closely resembled the Marseilles specimen. It should be noted that the citation by Wells of this species from Réunion Island (1963, p. 24) is more likely to apply to *H. parasigmoides* Bozic (1969) (=*H. sigmoides* in Bozic 1964).



Figs 27–30, *Heterolaophonte sigmoides*, ♀. Fig. 27, dorsal view; fig. 28, side view; fig. 29, ventral view of abdomen; fig. 30, operculum.



Figs 31–36. *Heterolaophonte sigmoides*, ♀. Fig. 31, R + 1A; fig. 32, A2; fig. 33, Md; fig. 34, Mxl; fig. 35, Mx; fig. 36, Mxp.



Figs 37–41. *Heterolaophonte sigmoides*, ♀. Fig. 37, P1; fig. 38, P2; fig. 39, P3; fig. 40, P4; fig. 41, P5.

The main differences between the Marseilles female and that of *H. wellsi* are shown in Table 1. Other noteworthy features in the former are: (1) the single posteroventral row of small needle-like spinules on each abdominal segment (fig. 29); (2) the richly developed combs of spinules on the exopods of P1 to P4 inclusive (figs 37–40); and (3) the shape of the rami of P5 (fig. 41). The remaining figures are presented here as a matter of record, against the day when a thorough knowledge of the range of variation in each sex, over as wide a geographical range as possible, will permit a deeper revision of the *quinquespinosa*-group. At present, the males are too poorly known to make them worth incorporating in a key; the following key refers only to females, and, if the Marseilles population should be found to have a spine on the basis of P1, then the difference between it and the Bermudan population disappears.

Of the three species of *Heterolaophonte* published since the most recent key (Lang, 1965, p. 468), *H. norvegica* Drzycimski (1968) leads to couplet 13 in Lang's key, whereas *H. parasigmoides* Bozic and *H. wellsi* nov. sp. both lead to couplet 26. However, because of the changes in synonymy discussed above, the following key is intended to replace couplets 25 to 27 inclusive of Lang's key.

Key to the **quinquespinosa** group of **Heterolaophonte** Lang (females only)

1. P1enp2, accessory seta longer than terminal claw .... *H. wellsi*
   P1enp2, accessory seta shorter than terminal claw 2

2. P1enp2 more than half as long as terminal claw .... *H. longifurcata*
   P1enp2 less than half as long as terminal claw 3

3. P1basis without a spine .... *H. quinquespinosa*—Marseilles
   P1basis with a spine 4

4. P3exp3 with one inner seta; P3,enp1 with an inner seta and enp2 with three inner setae; P4exp3 with a total of 6 spines and setae .... *parasigmoides*
   P3exp3 with two inner setae; P3, enp1 with no inner setae and enp2 with two inner setae; P4exp3 with a total of 7 spines and setae .... *H. quinquespinosa*—Bermudan

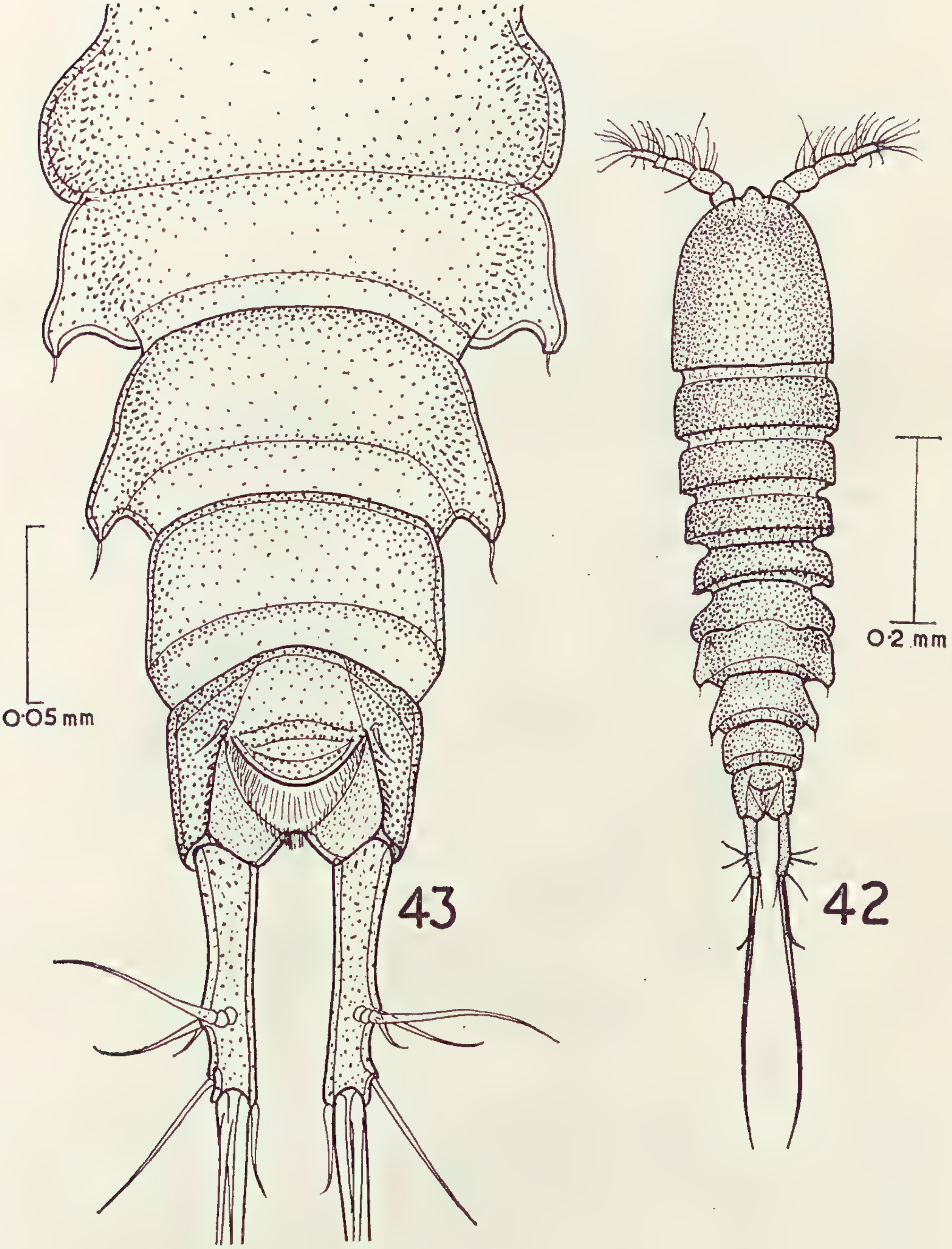
Redescription of **Onychocamptus bengalensis** (Sewell)

(Figs 42–65)

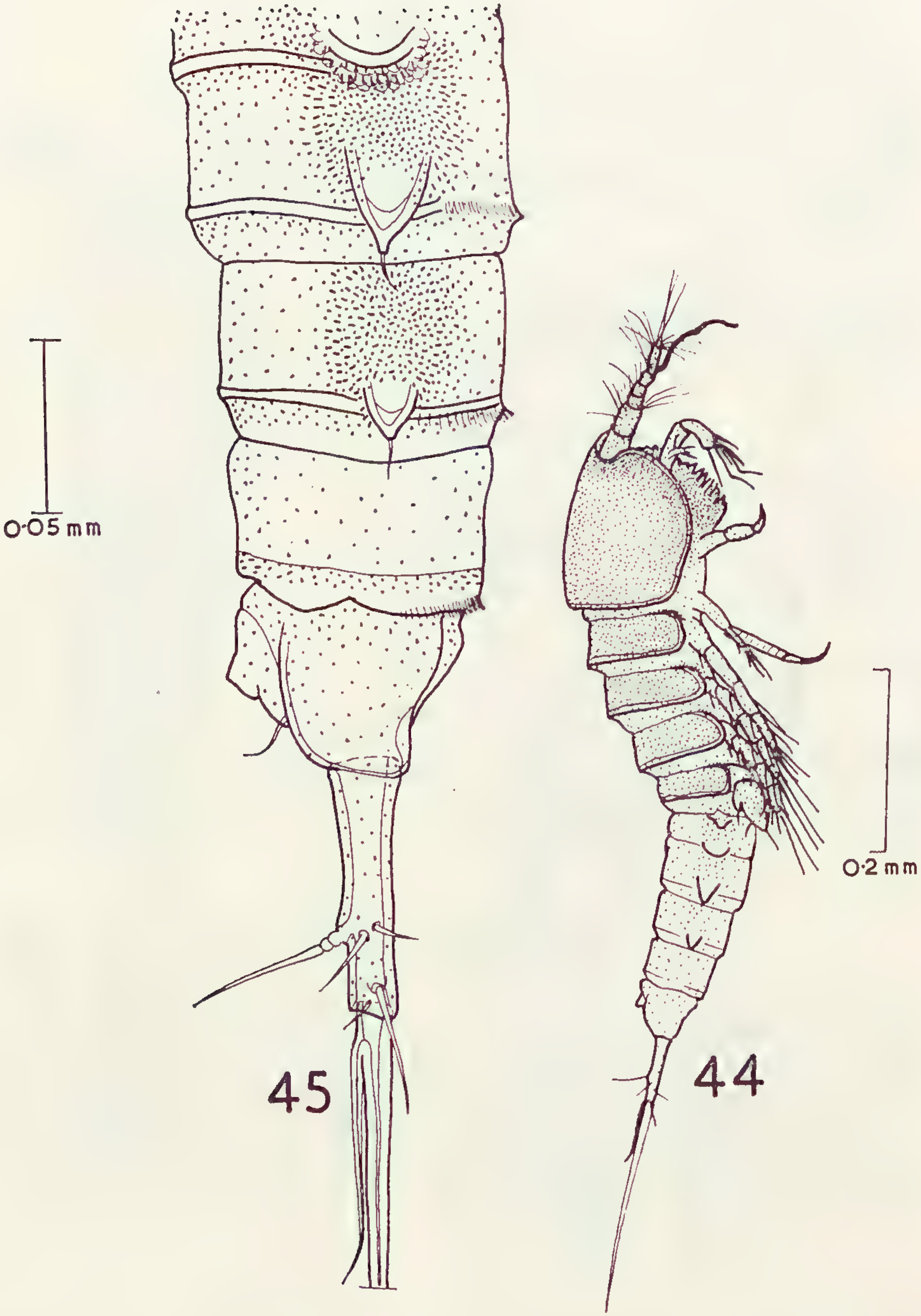
This species was well represented in the present series of samples (Table 2), and I have also found it in moderate numbers in brackish lagoons (Narrabeen, Manly, and Dee Why) in the northern coastal suburbs of Sydney. The original description (Sewell, 1934, from near Calcutta) is very incomplete, but fortunately includes one highly diagnostic character, the fused rami of the female P5 (remarked upon also by Bayly and Williams, 1966, p. 217, as *Onychocamptus* sp.), which appears to be unknown in any other laophontid. Although I have been unable to obtain any specimens from India, I can find no reason to doubt the specific identity of the Indian and Australian animals.

Description

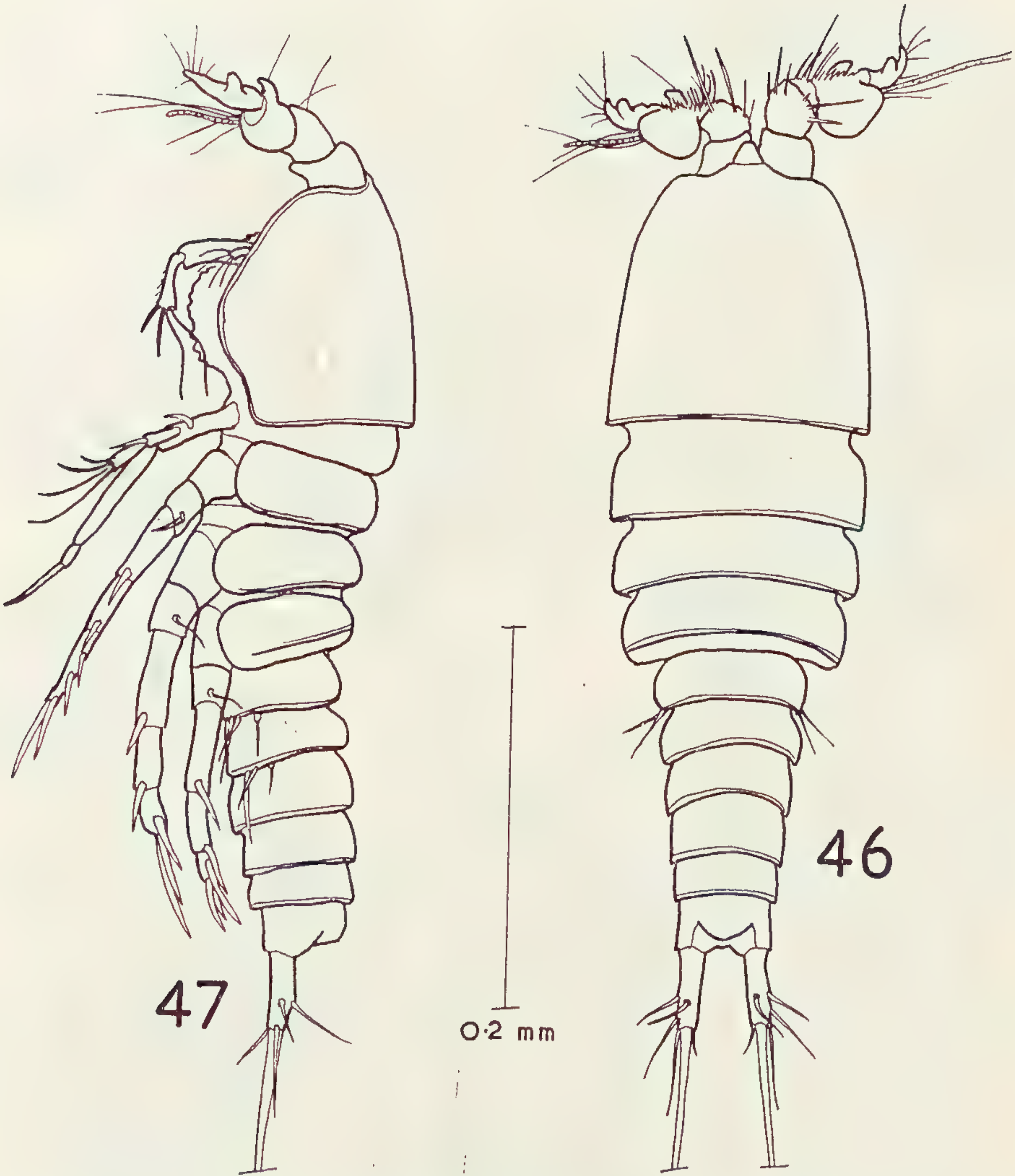
Adult female (figs 42–45, 51–61). Length 0.74 mm (in the female figured, from Narrabeen Lagoon, but most females are about 0.6 to 0.7 mm long). Body of the standard laophontid form, not compressed or flattened, the somites clearly demarcated; prosome only slightly wider than the rest of the body, and carrying an



Figs 42, 43. *Onychocamptus bengalensis*, ♀, dorsal view. Fig. 42, entire animal; fig. 43, abdomen with operculum and furca.



Figs 44, 45. *Onychocamptus bengalensis*, ♀, side view. Fig. 44, entire animal; fig. 45, abdomen and furca.



Figs 46, 47. *Onychocamptus bengalensis*, ♂. Fig. 46, dorsal view; fig. 47, side view.

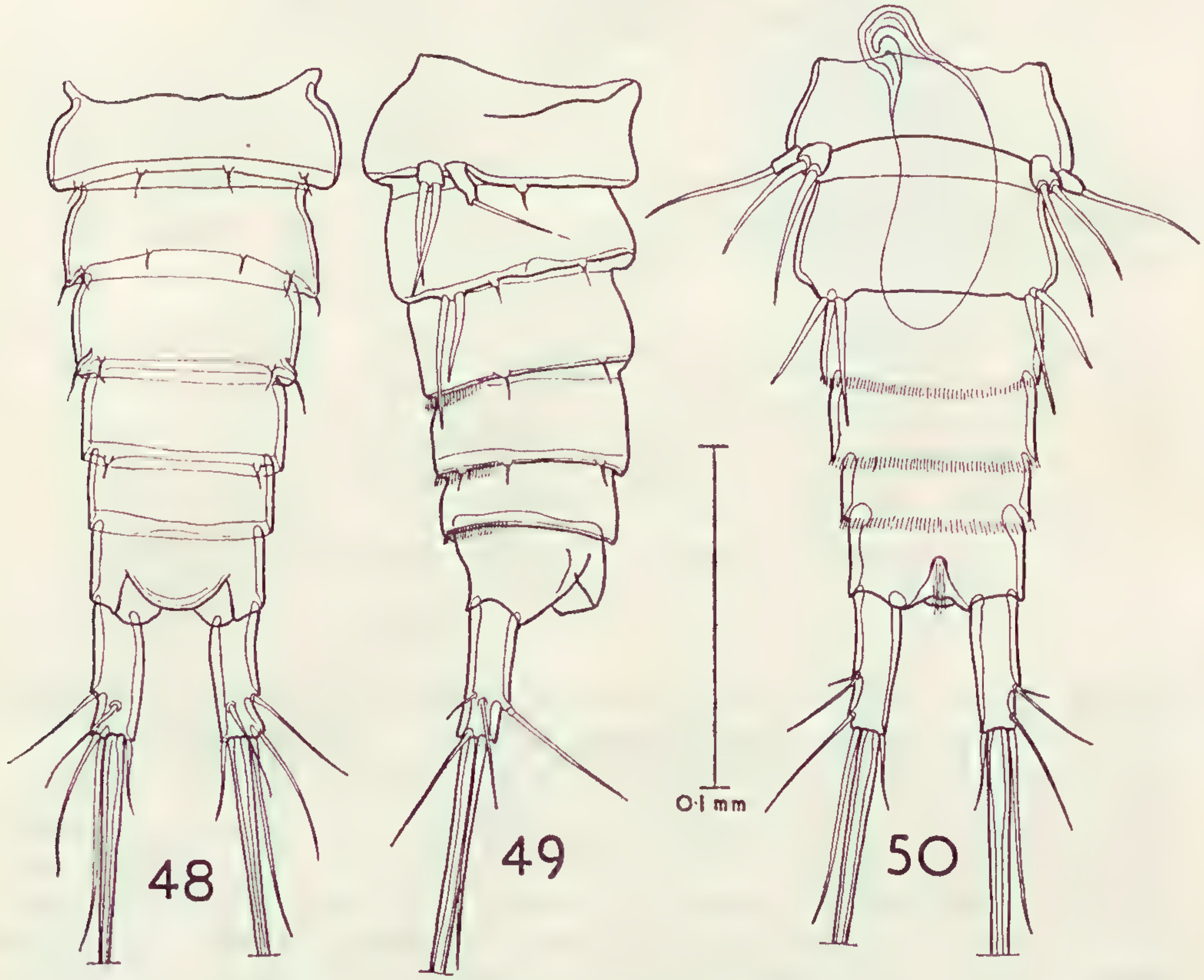
inconspicuous triangular rostrum. Genital double-somite broader than long, clearly divided, the rear half with a marked lateral keeltooth ending in a sensilla (as on the somite behind it; figs 42, 43). The rear half of the double-somite, and each of the somites behind it, bears a ventrally complete comb of spinules on the rear margin (fig. 45, ♀; Figs 49, 50, ♂). Operculum (unknown to Lang, 1948) deeply curved, with a smooth edge (fig. 43). Caudal rami about six times as long as broad in dorsal view; the middle terminal furcal seta in the present female is about as long as the abdomen and furca combined (much more than this, in other females), the other furcal setae all being short. The short uppermost terminal furcal seta appears to be fused at its base with the large furcal seta (Figs 43, 45); otherwise, none of the furcal setae present any unusual features.

Antennule (fig. 51) with five segments, of which the third bears the aesthetasc. Antenna (fig. 52) with a terminal group of setae of which one (kinked in other females) is straight, two are kinked, and two are hooked at the tip; one of these last two is much longer than the other. Subterminally, there are two more short hooked setae and a simple seta. The allobasis bears a single-segmented exopod with two lateral and two terminal setae, all four setae being coarsely plumose. Mandible (fig. 53) with a small single-segmented exopod bearing five setae; maxillules (fig. 54) not remarkable; maxillae (fig. 55) with an area on the precoxa covered with irregular rows of small spinules; maxillipede (fig. 56) with a strong claw, as long as the palm.

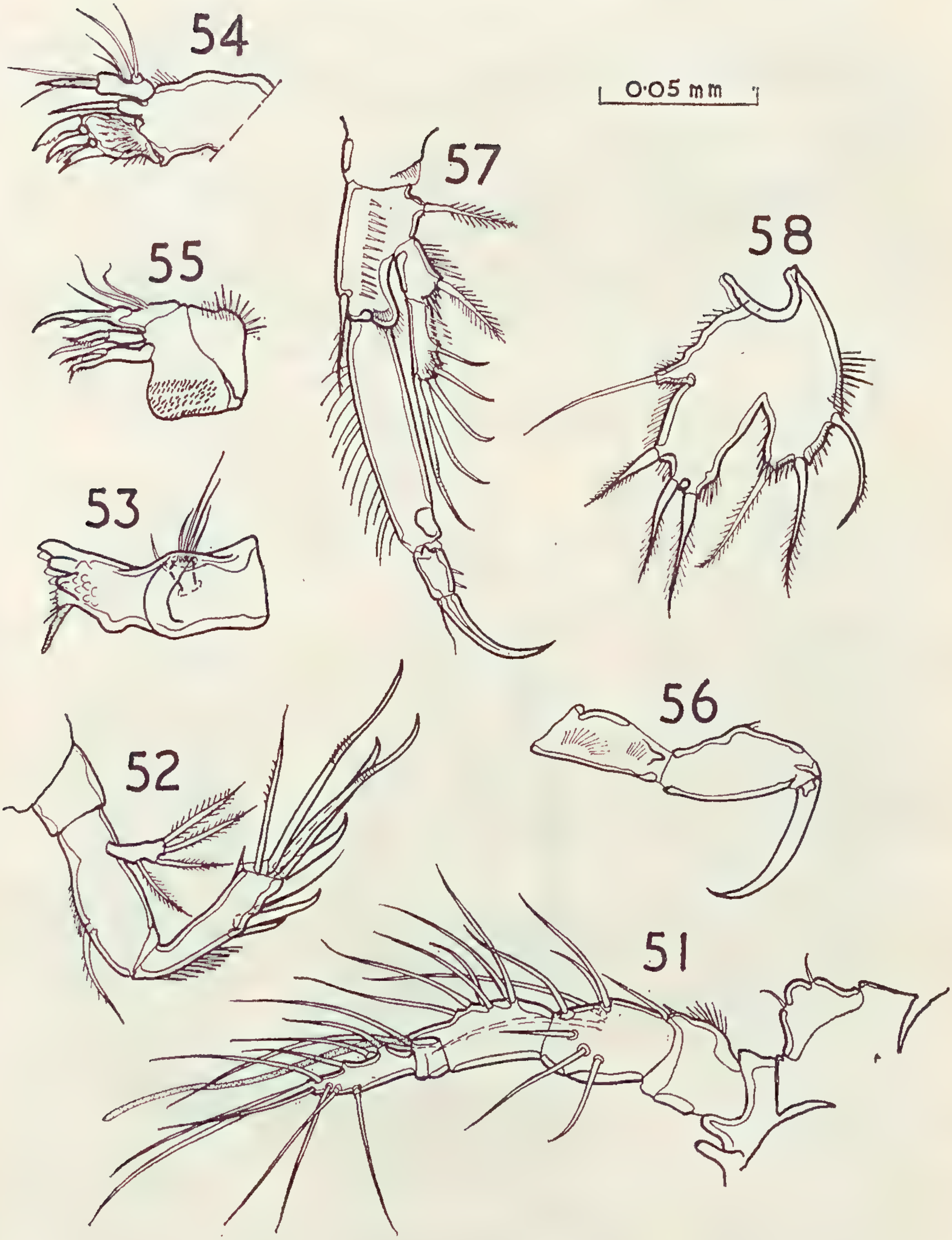
P1 (fig. 57) with a two-segmented exopod whose distal segment bears three spines and two terminal kinked setae, all five appendices being smooth; the strongly built two-segmented endopod bears a heavy claw and a very slender accessory setae, both terminally.

Swimming legs with three-segmented exopods and two-segmented endopods, the latter being much shorter than the exopod on each leg. Setal formula:

P2 (fig. 59)		P3 (fig. 60)		P4 (fig. 61)	
exp	enp	exp	enp	exp	enp
0.1.123	0.220	0.1.123	0.321	0.1.123	0.120 or 0.111



Figs 48, 50. *Onychocamptus bengalensis*, ♂, abdomen. Fig. 48, dorsal view; fig. 49, side view; fig. 50, ventral view.



Figs 51–58. *Onychocamptus bengalensis*, ♀. Fig. 51, R + A1; fig. 52, A2; fig. 53, Md; fig. 54, Mxl; fig. 55, Mx; fig. 56, Mxp; fig. 57, P1; fig. 58, P5.

I am unable to decide the true arrangement of the terminal endopod setae of P4, and therefore alternatives are given.

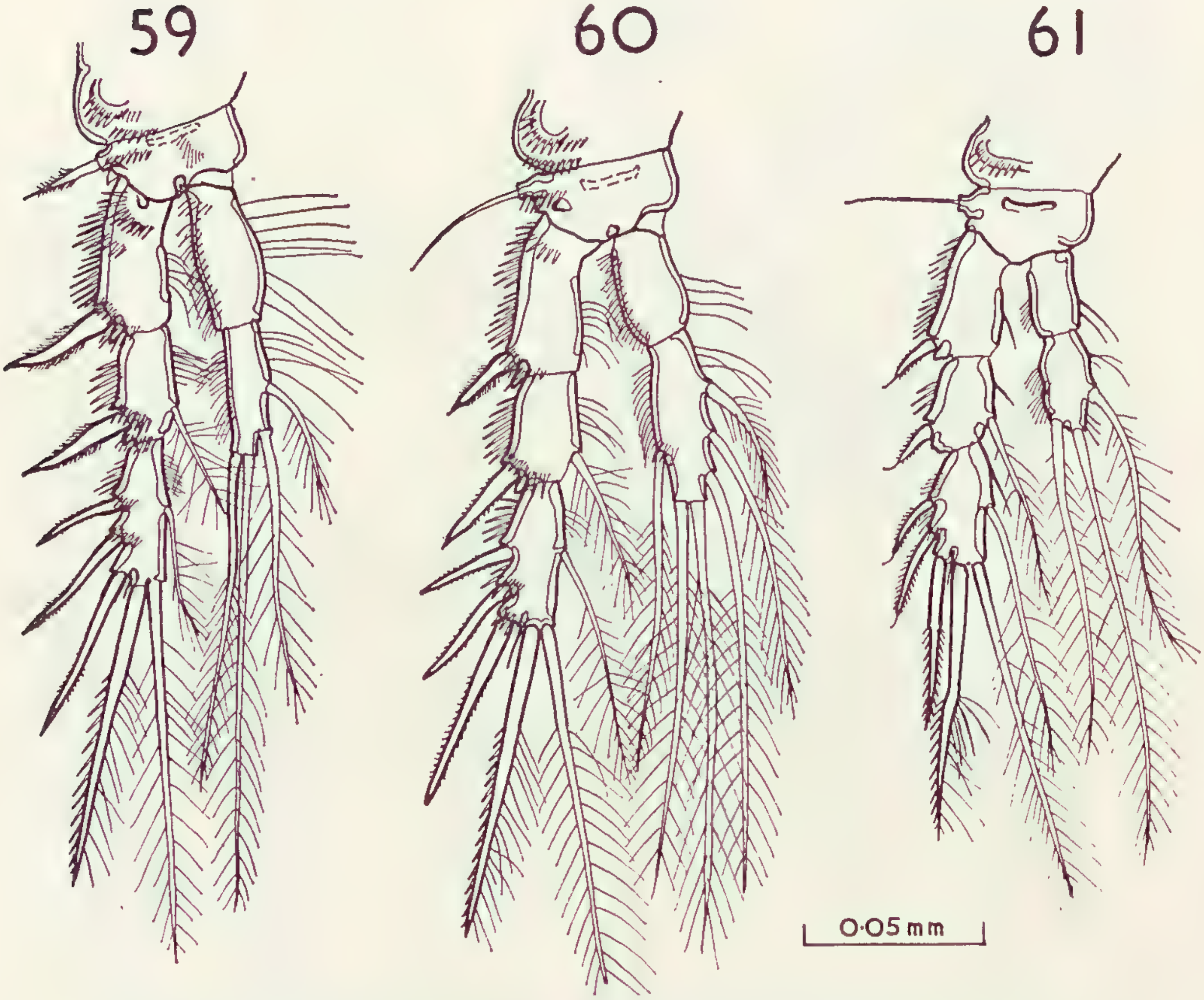
P5 (fig. 58) with fused rami; each ramus bears three coarsely plumose setae.

Adult male (figs 46–50, 62–65). Length 0.46 mm (Table 2, locality 12); abdomen much slenderer, compared with the rest of the body, than in the female. Antennule (fig. 62) indistinctly six- or seven-segmented, the fourth segment inflated and bearing the aesthetasc.

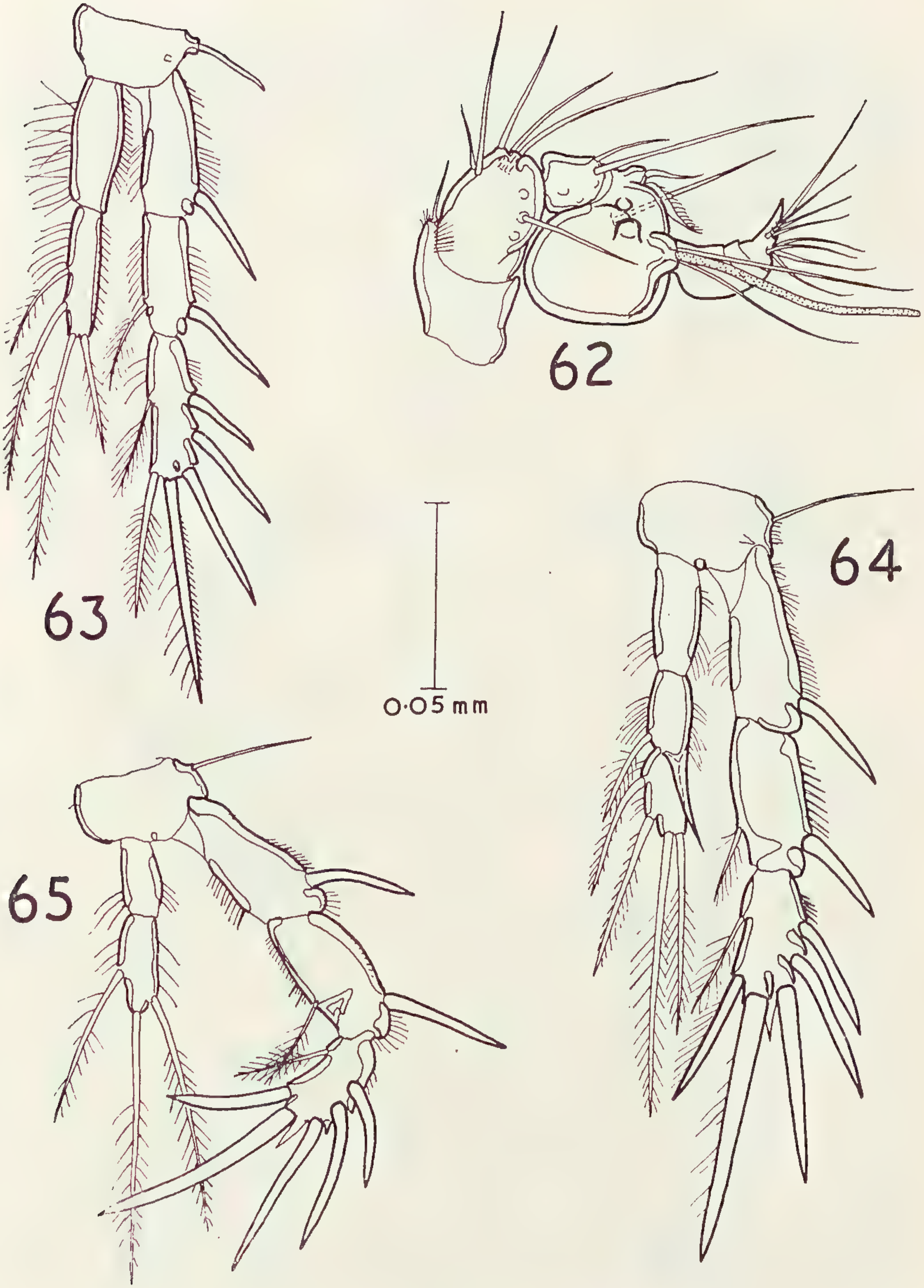
In both sexes from the samples listed in Table 2, the P1 was much slenderer (fig. 47) than in the female described above from Narrabeen Lagoon; unfortunately, no males from the Sydney area are yet available for comparison.

P2 (fig. 63) very much as in the female; P3 (fig. 64) and P4 (fig. 65) with heavily built exopods, that of P4 being strongly incurved. Setal formula as in the female, except that the two distal endopod segments of P3 are discrete, the formula for this endopod in the male thus being 0.1.220; the middle segment of this endopod has a tapering adaxial thorn reaching to slightly beyond the end of the distal segment.

P5 and P6 (figs 49, 50) each with two simple setae.



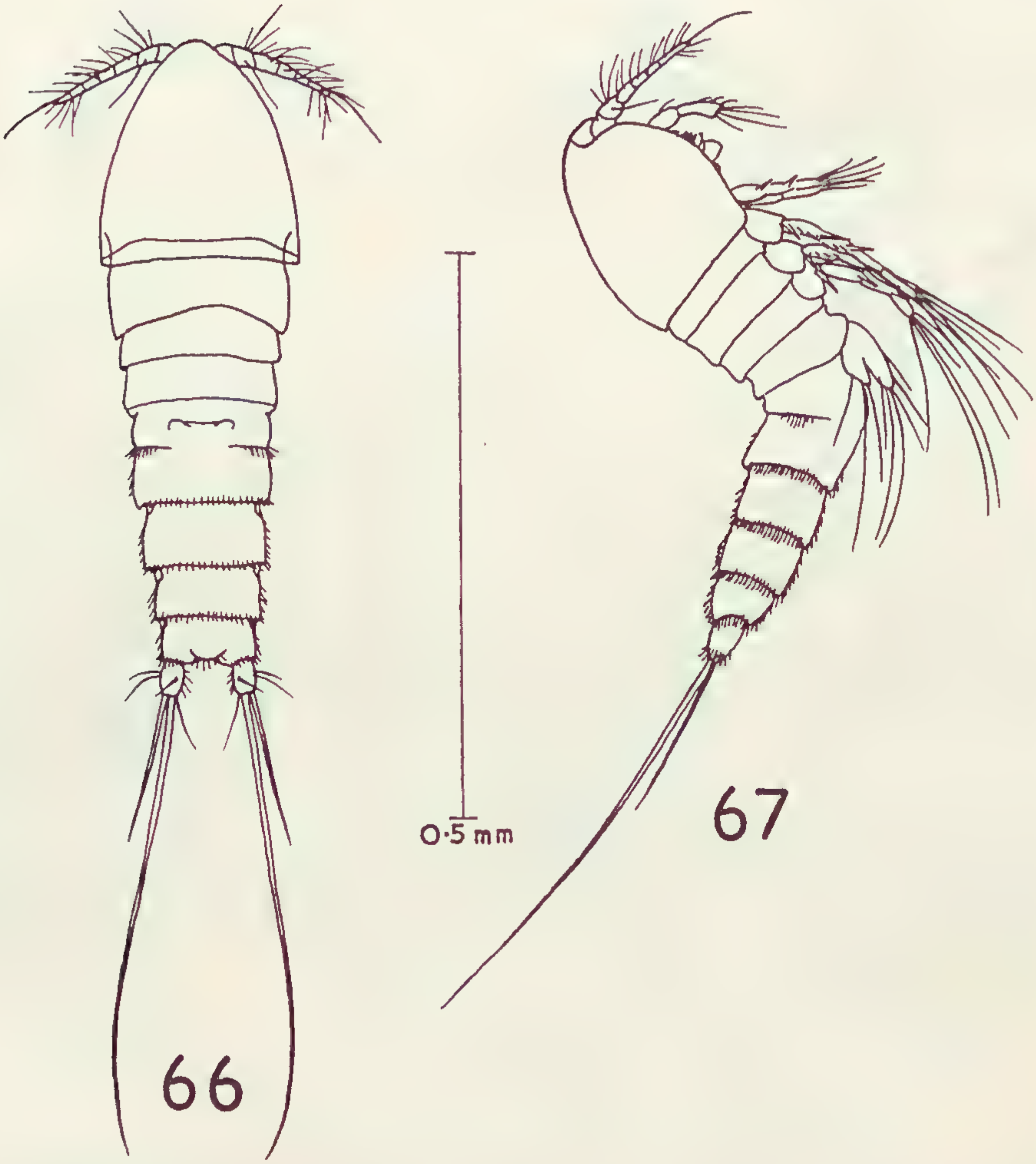
Figs 59–61. *Onychocamptus bengalensis*, ♀. Fig. 59, P2; fig. 60, P3; fig. 61, P4.



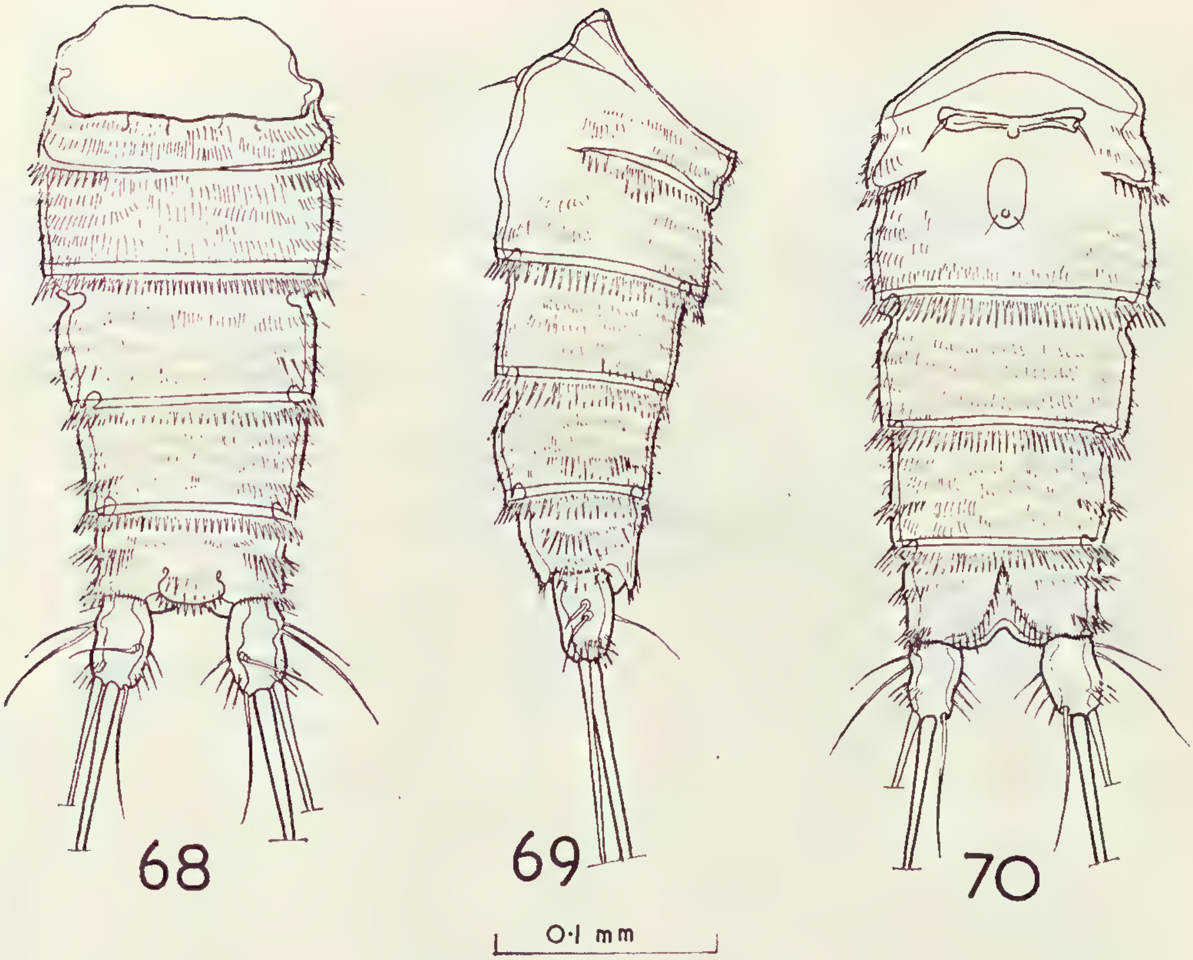
Figs 62–65. *Onychocamptus bengalensis*, ♂. Fig. 62, A1; fig. 63, P2; fig. 64, P3; fig. 65, P4.

Cletocamptus deitersi (Richard) (Figs 66–81)

The figures are presented merely as proof of the presence of this South American species in Australia, where it has not previously been recorded; the single female, from locality 10E, was indistinguishable from Jamaican specimens (now in the United States National Museum) which I have recently examined, and all agreed so closely with the descriptions in Lang (1948) and Yeatman (1963) as to make a detailed description unnecessary. The only species of this genus not in Lang's monograph is *C. xenuus* Por (1958), which is very different in many ways from *C. deitersi.*



Figs 66, 67. *Cletocamptus deitersi,* ♀. Fig. 66, dorsal view; fig. 67, side view.



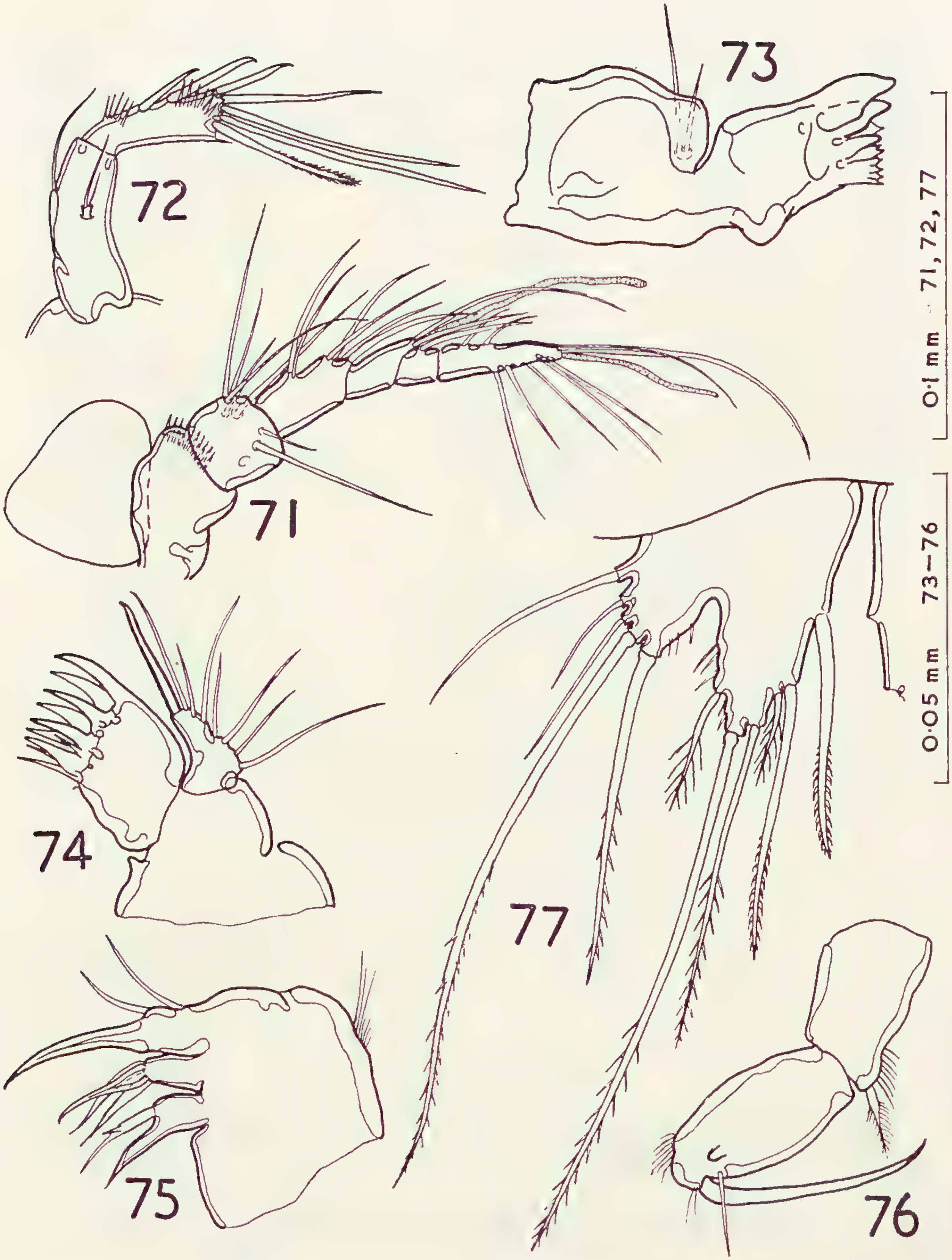
Figs 68–70. *Cletocamptus deitersi*, ♀, abdomen. Fig. 68, dorsal view; fig. 69, side view; fig. 70, ventral view with genital area.

The female from 10E showed the following states of characters, which in this species are notoriously variable:

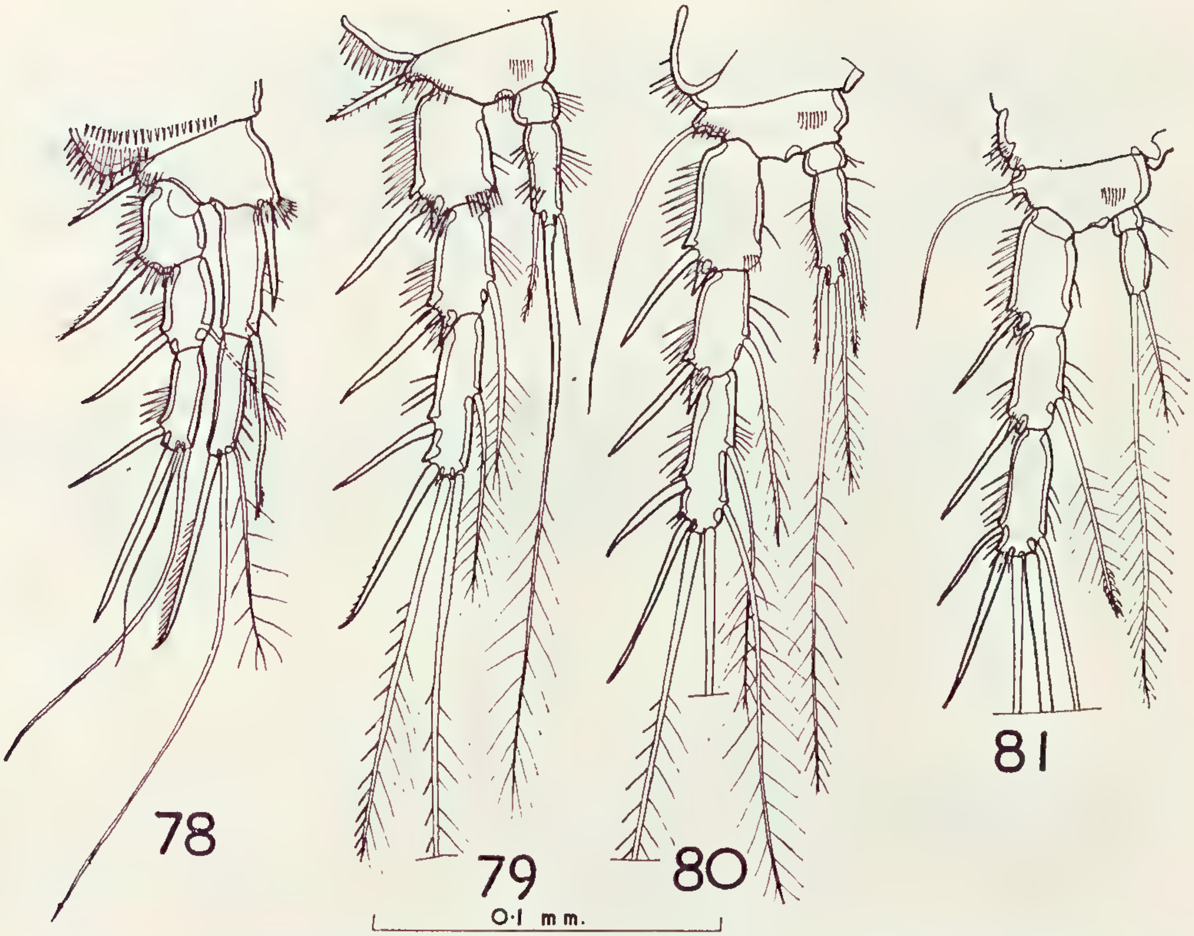
(1) The antennal exopod (fig. 72) on one side of the animal is of a single segment, bearing two simple terminal setae of which the adaxial is the shorter; the exopod of the other antenna could not be seen clearly;

(2) The site of the mandibular palp (fig. 73) gives rise to two simple setae; and

(3) P5 (fig. 77) has five exopod setae and six basiendopod setae.



Figs 71–77. *Cletocamptus deitersi*, ♀. Fig. 71, R + A1; fig. 72, A2; fig. 73, Md; fig. 74, Mxl; fig. 75, Mx; fig. 76, Mxp; fig. 77, P5.



Figs 78–81. *Cletocamptus deitersi*, ♀. Fig. 78, P1; fig. 79, P2; fig. 80, P3; fig. 81, P4.

ECOLOGY

In a letter dated 14.4.1970, Dr Bayly states, "Locality 10E is the only one that is not 'athalassic' in the sense that I defined it in 1966 (Bayly and Williams, 1966, p. 178) and 1967 (chapter 3 in Weatherly, 1967). . . . It is an 'open' locality connected with the sea by a stream; the salinity was 15.8‰."

In a letter dated 11.5.1970, he gives the following ecological details: "All collections were made by casting a net from the lake shore or by wading about in shallow water with the net held just above the bottom, so that they are 'littoral' collections in the normal sense of the word. However, you must realise that, in more highly saline lakes, there is frequently no littoral vegetation, and conditions are very uniform in a horizontal direction from one extreme shoreline to that opposite. In other words, it is most unlikely that a collection taken from the middle of a highly saline lake would differ very significantly from a 'littoral' collection. It should also be borne in mind that all of the Beachport-Robe lakes are very shallow, and if weed occurs near the shore it also occurs all over the lake. All collections in December 1969, except those from localities 10 and 12, were from highly weedy localities. Localities 10 and 12 were not weedy, and harpacticoids would have been caught because the net was just above the bottom, and walking in front of it would have disturbed the bottom sediments. With respect to September 1966, locality 16B was definitely without any weeds (you never find any filamentous algae or higher plants in the large localities 10A and 16B). A significant fact now emerges, namely that *Heterolaophonte wellsi* has been collected only from high-salinity localities lacking weeds; it therefore appears to be a bottom-sediment-dweller, rather than a weed-dweller. In March 1964, locality 12 (which yielded quite large numbers of *M. baylyi* and *O. bengalensis*, and small numbers of *R. propinqua*) had a thick growth of filamentous algae".

ACKNOWLEDGEMENTS

I am most grateful to Dr I. A. E. Bayly (Monash University) for sending me the samples and all necessary ecological information, for his help during the course of the work, and for his constructive criticisms of the completed typescript. Thanks are also due to the Chief of the Division of Fisheries and Oceanography, CSIRO, for the loan of phase-contrast equipment.

REFERENCES

Bayly, I. A. E., 1970. Further studies on some saline lakes of south-east Australia. *Aust. J. mar. Freshwat. Res.* 21: 117–129.

Bayly, I. A. E. and Williams, W. D., 1966. Chemical and biological studies on some saline lakes of south-east Australia. *Aust. J. mar. Freshwat. Res.* 17: 177–228.

Bodin, P., 1964. Recherches sur la systématique et la distribution des copépodes harpacticoides des substrats meubles des environs de Marseille. *Rec. Trav. Stn mar. Endoume* 51 (Bull. 35): 107–183.

Bozic, B., 1964. Copépodes harpacticoides et cyclopoides de La Réunion, II. Plage Saint-Pierre. *Bull. Mus. natn Hist. nat. Paris* (2), 36: 481–499.

Bozic, B., 1969. Copépodes harpacticoides de La Réunion, VI. *Bull. Mus. natn Hist. nat. Paris* (2) 41: 867–882.

Drzycimski, I., 1968. Neue Harpacticoida (Copepoda) aus dem west-norwegischen Küstengebiet. *Sarsia* 31: 15–24.

Hamond, R., 1969. Methods of studying the copepods. *J. Quekett microsc. Club* 31: 137–149.

Hamond, R., 1971. The Australian species of *Mesochra* (Crustacea: Harpacticoida), with a comprehensive key to the genus. *Aus. J. Zool.* (Suppl. 7): 1–32.

Hamond, R., (in press). The Australian species of *Robertsonia* (Crustacea, Harpacticoida). *Rec. Aust. Mus.*

Kiefer, F., 1967. Cyclopiden aus salzhaltigen Binnengewässern Australiens (Copepoda). *Crustaceana* 12: 292–302.

Lang, K., 1948. *Monographie der Harpacticiden.* Nordiska Bokhandeln, Stockholm.

Lang, K., 1965. Copepoda Harpacticoidea from the Californian Pacific coast. *K. svenska Vetensk Akad. Handl.* (4), 10 (2): 1–560.

Por, F. D., 1968. Copepods of some land-locked basins in the islands of Entedebir and Nocra (Dahlak Archipelago, Red Sea). *Bull. Sea Fish. Res. Stn Israel* 49: 32–50.

Sewell, R. B. S., 1934. A study of the fauna of the salt lakes, Calcutta. *Rec. Ind. Mus.* 36: 45–121.

Weatherley, A. H., 1967. *Australian inland waters and their fauna; eleven studies.* A.N.U. Press, Canberra.

Wells, J. B. J., 1963. Copepoda from the littoral region of the estuary of the River Exe (Devon, England). *Crustaceana* 5: 10–26.

Yeatman, H. C., 1963. Some redescriptions and new records of littoral copepods for the Woods Hole, Massachusetts region. *Trans. Am. microsc. Soc.* 82: 197–209.

TABLE 1

Differences between the females of *Heterolaophonte sigmoides* (from Marseilles) and *H. wellsi*

Character	*sigmoides*	*wellsi*
A2exp	absent; site indicated only by two setae	present, with 3 setae
P1basis, inner spine	absent	present
P1exp2, inner terminal seta	straight, and shorter than outer terminal seta	curving outwards, longer than outer terminal seta
P1enp2, terminal claw	stout, curved along whole length	slender, straight for most of length but with curved tip
P1enp2, seta next to claw	much shorter than claw	longer than claw
P2–P4, inner setae of exopods	long and pinnate	short and bare
P4exp3, inner setae	2	1
P4,enp2 reaches as far as	end of exp1	end of exp2
P4enp2, outer seta	present	absent (but present on one side of female paratype 1)
P5,benp reaches	not quite to end of exp	level with end of exp, or even slightly beyond it

TABLE 2

Copepods in the saline lake samples, collected by Dr Bayly

Locality number	2	4	6	10	10A	10B	10C	10E	12	12	13	13	13	13	14	15	15A	15B	16	16B
Date	March 1964			29.12. 1969	3.9. 1966	as 10	27.12. 1969	2.1. 1970	as 2	as 10	as 2	1.3. 1964	as 10A	as 10	as 2	as 10	31.12. 1969	as 10	as 2	as 10A
Halicyclops ambiguus Kiefer	2 juv.					3,1, 0,1.	34,14, 0,0.	few	7,0, 1,0.		2,1, 0,0.	1 juv.				19,7, 0,0.	many			
Amphiascoides nov. sp.								1,0. 1,0.												
Robertsonia propinqua (T. Scott)						4,2, 2,0.			7,0, 0,0.	1,0, 1,0.	5,0, 3,0.	0,0. 0,1.	0,0. 1,1.							
Mesochra baylyi Hamond	14,5, 0,0.	28,9, 0,0.	9,8, 0,0.	1,0, 0,0.	7,1, 0,0.	6*,3, 2,2.		6,5, 0,0.	11,4, 1,0.	2,2, 0,0.	4,2, 0,0.			2,1, 0,0.		17,3, 1,2.	1,0, 0,0.	1,0, 0,0.	7,0, 0,0.	30,4, 6,3.
Cletocamptus deitersi (Richard)								1,0, 0,0.												
Heterolaophonte wellsi nov. sp.				3,1, 0,18.																8,1, 2,1.
Onychocamptus bengalensis (Sewell)				1,0, 0,0.		1,0, 0,0.	5,1, 1,0.	1,0, 0,0.	18*,0, 8,2.	4,0, 3,3.	12,0, 4,0.	2,0, 5,0.	4,0, 0,0.		1,0, 5,2.					
Total species 7	2	1	1	3	1	4	2	5	4	3	4	3	2	1	1	2	2	1	1	2

NATIONAL MUSEUM
17 AUG 1973
OF VICTORIA

THE AUSTRALIAN SPECIES OF ROBERTSONIA (CRUSTACEA, HARPACTICOIDA), WITH A REVISED KEY TO THE GENUS

By R. Hamond

Department of Zoology, Melbourne University, Victoria

Figures 1–41. Manuscript received, 28th March, 1972.

SUMMARY

Two species of copepods of the genus *Robertsonia* are described and figured, *R. propinqua* (T. Scott) from saline lakes in south-east Australia and *R. barnesi* sp. nov. from the intertidal zone of north-eastern Queensland. A new key to all known species of the genus is provided.

Rec. Aust. Mus., **28**, page 421.
49018—A

INTRODUCTION

As at present constituted (see below), the genus *Robertsonia* contains thirteen species, found in brackish coastal lagoons and in shallow marine waters in many parts of the world (according to the ecological summaries given for each species by Lang 1948, and by the authors of subsequent species as listed in Bodin 1967). The only previous record of an Australian *Robertsonia* is that of *R. monardi* by Nicholls (1945, as *R. paramonardi* n. sp.; I agree with Noodt 1955, p. 64, that there is no valid reason for separating these two species).

In the present paper two more species are recorded from Australia; *R. propinqua* (Scott) is redescribed from South Australia and *R. barnesi* sp. nov. is described from north-eastern Queensland. Type material is in the Australian Museum; all other material of these species, examined by me, is kept in my own collection for purposes of comparison. Abbreviations and methods of study were as in Hamond (1969, 1971); for material and methods, see Hamond (1973).

TAXONOMY

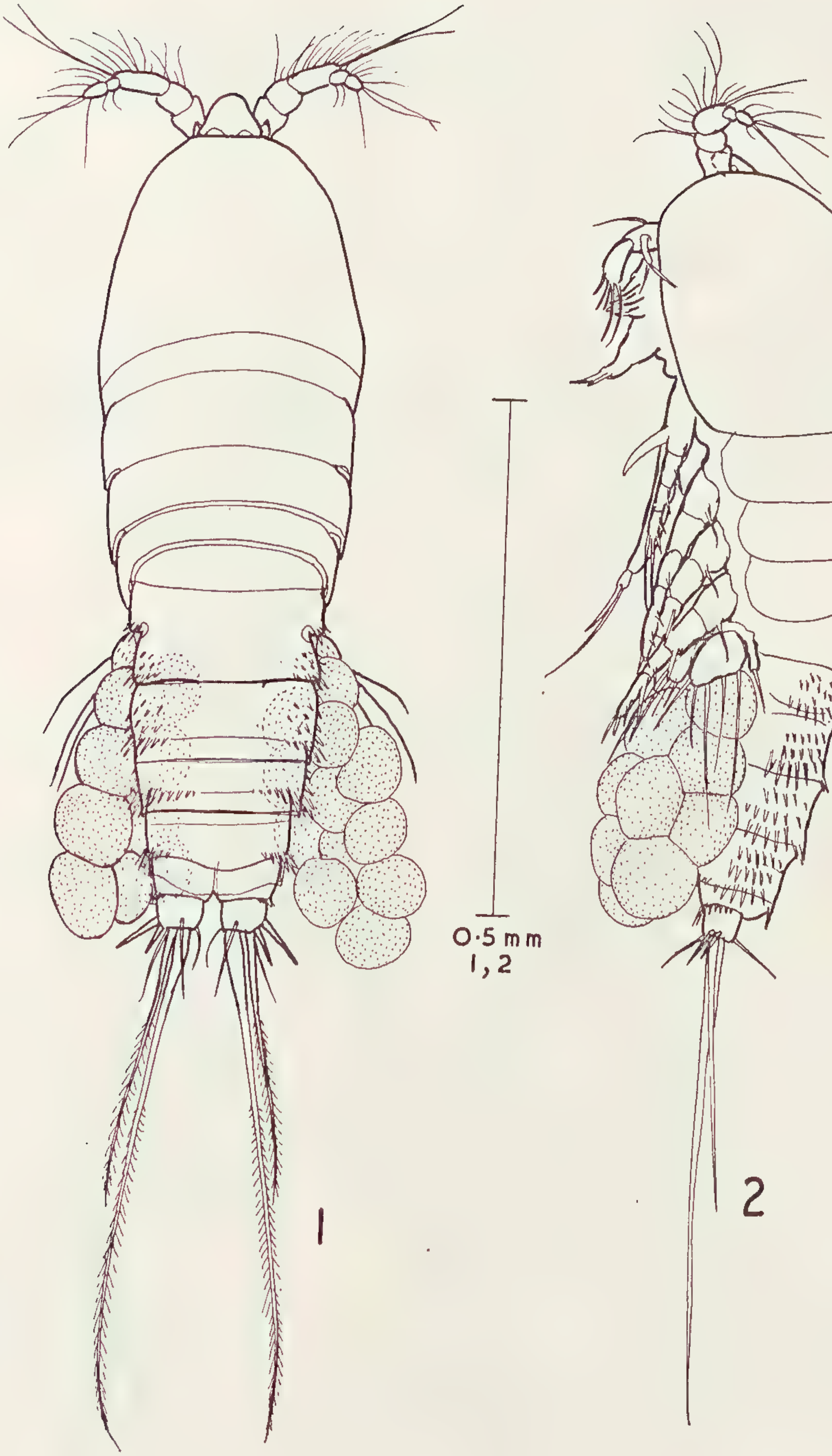
Robertsonia propinqua (T. Scott) (Figs 1–28).

Robertsonia sp. Bayly (1970, p. 125).

Redescription

Adult female. Length 0.81 mm. Body stout, prosome noticeably the widest part of the animal, the abdomen tapering from thorax to tail. Spinules on abdomen unusually large and abundant (figs 3–5), the lateral combs having by far the longest spines as well as the largest numbers of shorter spines. Genital area and spermatophore as in fig. 3; genital double-somite not divided except for an indistinct dorsal division. Operculum very difficult to see, but apparently smooth-edged; the delicately fimbriated rear margin of the pre-anal somite is drawn back over the anal somite on all sides, and extends caudally on the dorsal side more than elsewhere, in order to form a broad pseudoperculum. Furcal ramus broader than long in dorsal view, the rami separated by less than the width of one of them; each ramus carries two outer spines (of which the outermost alone has an aristate tip), three slender simple setae in the dorsal, innermost terminal, and ventral positions respectively, and two large bipinnate furcal setae inserted terminally. Rostrum triangular, with broadly rounded basal corners.

Antennule (fig. 11) with five segments, of which the third bears the aesthetasc, and the most distal segment has two unilaterally pinnate setae on its front surface and five small forked setae on its rear surface, all other antennular setae being simple. Antenna (fig. 13) with one long spinulose kinked spine subterminally, three unornamented kinked spines and a straight spine in a terminal group, and two more straight spines together with some spinules on the inner side; arising from about the same level on the allobasis are a seta and the two-segmented exopod, whose basal segment has a lateral seta and whose distal segment carries one lateral and three terminal setae. Mandible (fig. 14) with both rami well developed; maxillules (fig. 15) and maxillae (fig. 16) not remarkable; maxillipede (fig. 17) with two setae on the basis, and with an inwardly-directed spur on the claw.



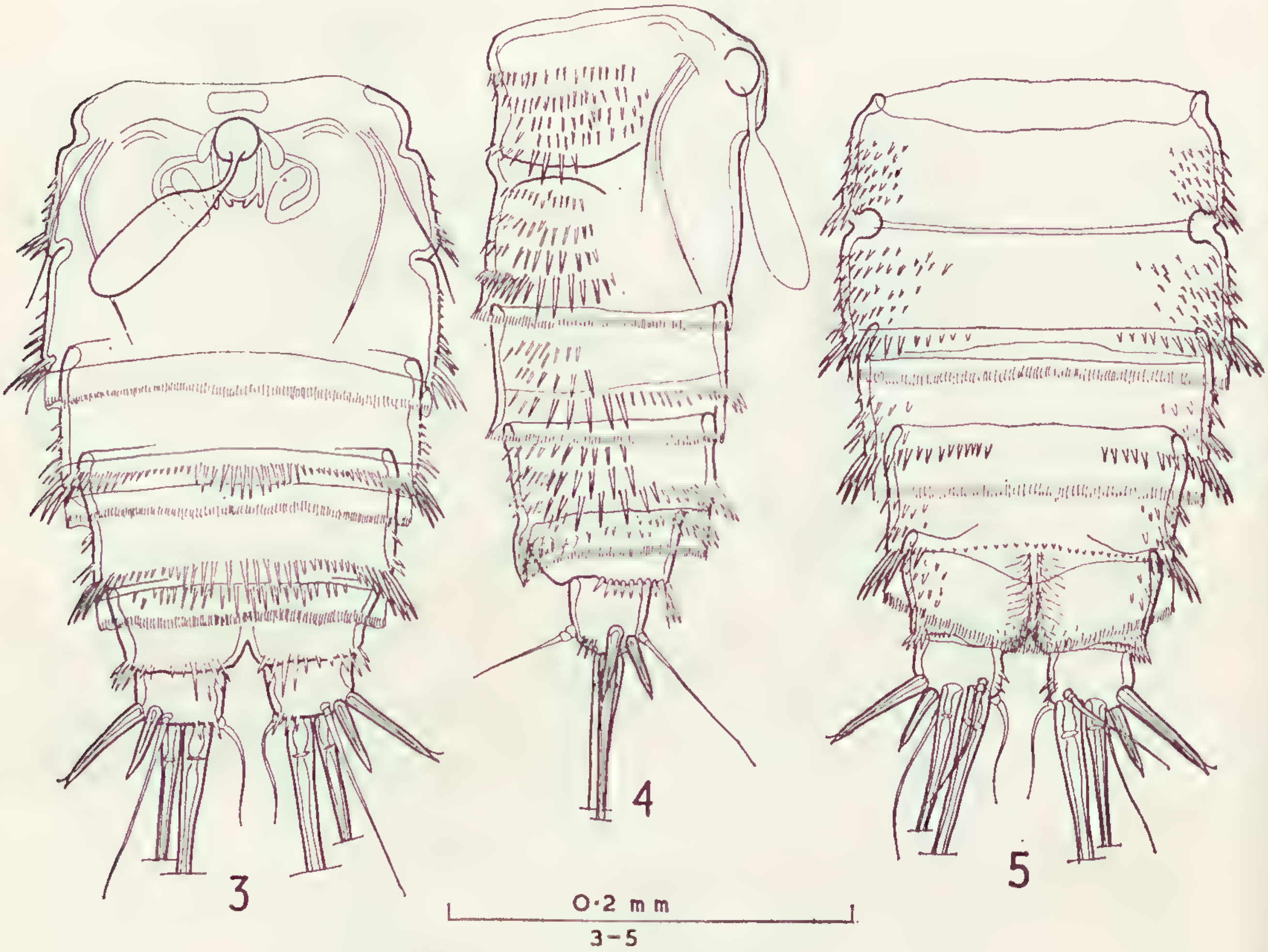
Figs 1, 2. *R. propinqua*, ♀. 1, dorsal view; 2, lateral view.

P1 (fig. 20) with both rami three-segmented; the middle exopod segment has an inner seta, and the terminal segment has four spines and a terminal seta. Swimming legs (figs 21–23) with both rami three-segmented; in P4 the endopod is very much shorter in relation to the exopod, than it is in P2 or P3. Setal formula:

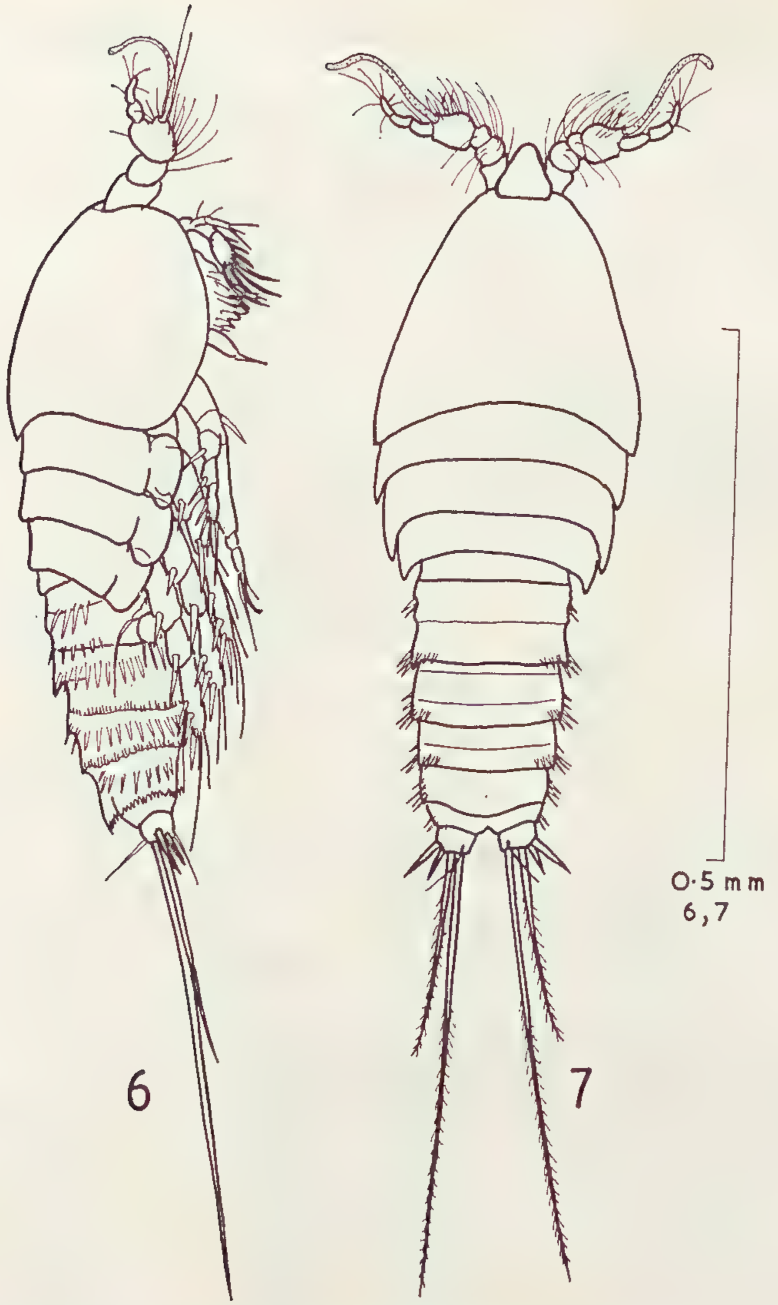
P2 (Fig. 21)		P3 (Fig. 22)		P4 (Fig. 23)	
exp	enp	exp	enp	exp	enp
1.1.223	1.1.121	1.1.223	1.1.321	1.1.323	1.1.221

In P4 (and to a slightly less extent in P3) the second inner seta of the distal exopod segment is thickened, and heavily pectinate near its tip on the adaxial side only.

P5 (fig. 19) with both rami about equal in length; exopod with six setae, of which the inner apical seta is much the longest; basiendopod with five setae, of which the innermost but one has a forked tip. The two apical exopod setae are completely smooth, all other setae on both rami being minutely bipinnate throughout their length except for a smooth basal portion. Both rami have prominent hyaline fields, shown dotted.



Figs 3–5. *R. propinqua*, ♀, abdomen. 3, ventral view; 4, lateral view; 5, dorsal view.



Figs 6, 7. *R. propinqua*, ♂. 6, lateral view; 7, dorsal view.

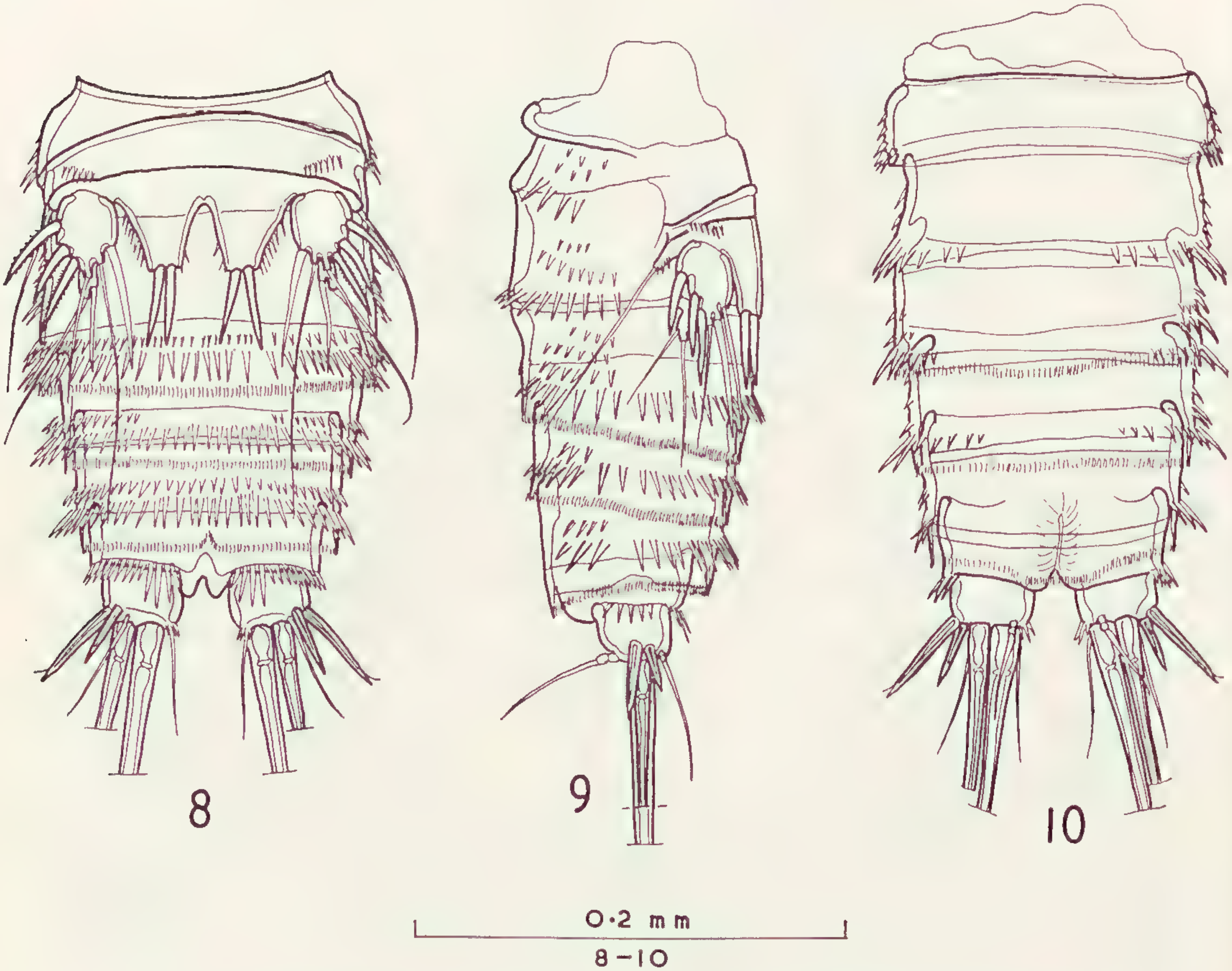
Adult male

Length 0.67 mm, with a more noticeable "waist", and a far more heavily ornamented abdomen, than the female; the spines on the abdomen tend to form girdles which are incomplete dorsally (figs 6–10). Antennule (fig. 12) with seven segments; the fourth segment bears a large aesthetasc, and two stout setae covered with spinules near their tips; a smaller aesthetasc arises from the front of the third segment. The distal segment carries three forked setae on its front surface; simple setae are found on all the segments.

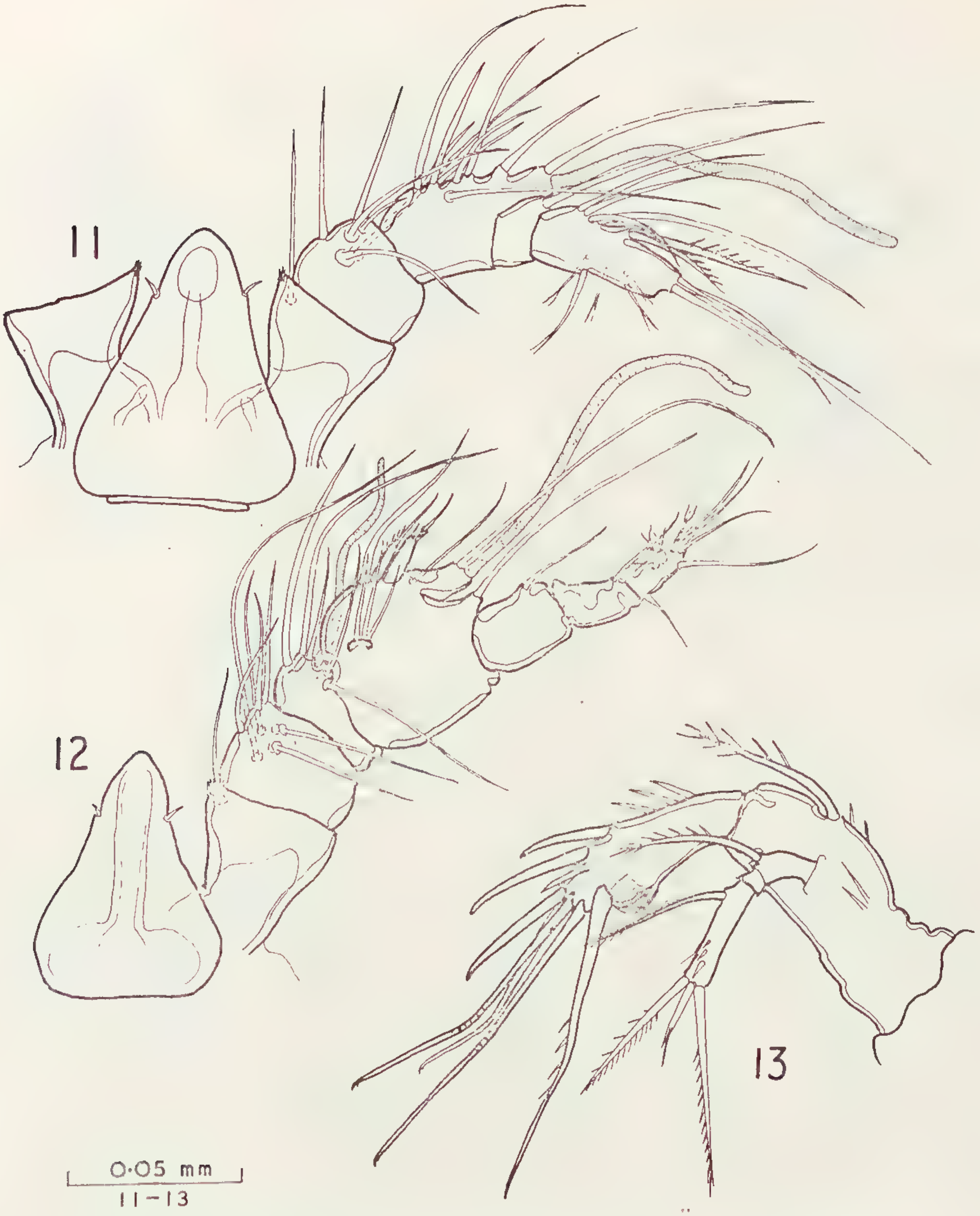
P1 (fig. 24) with a basal spine which is slightly curved outwards (instead of being straight, as in the female) and just adaxially to it a chitinous knob with lengthwise striations (fig. 25). P2 (fig. 26) with the endopod modified as usual (figs 27, 28). P5 (fig. 18) with two aristate and bipinnate spines on the basiendopod, and with six setae (of which the outer three are spiniform) on the exopod; both rami are about the same length, and each has a hyaline field, the exopodal field being much the smaller. P6 in the form of a narrow plate, with a prominence from which arise three setae.

Distribution

This species was found in small numbers in localities 10B (December), 12 (March), and 13 (March, September) of Bayly and Williams (1966, fig. 1); ovigerous females were found only at 10B, but for such a scarce species the negative data probably reflect paucity of observation rather than seasonality of reproduction. For salinity tolerances, see Bayly (1970: 124–5).



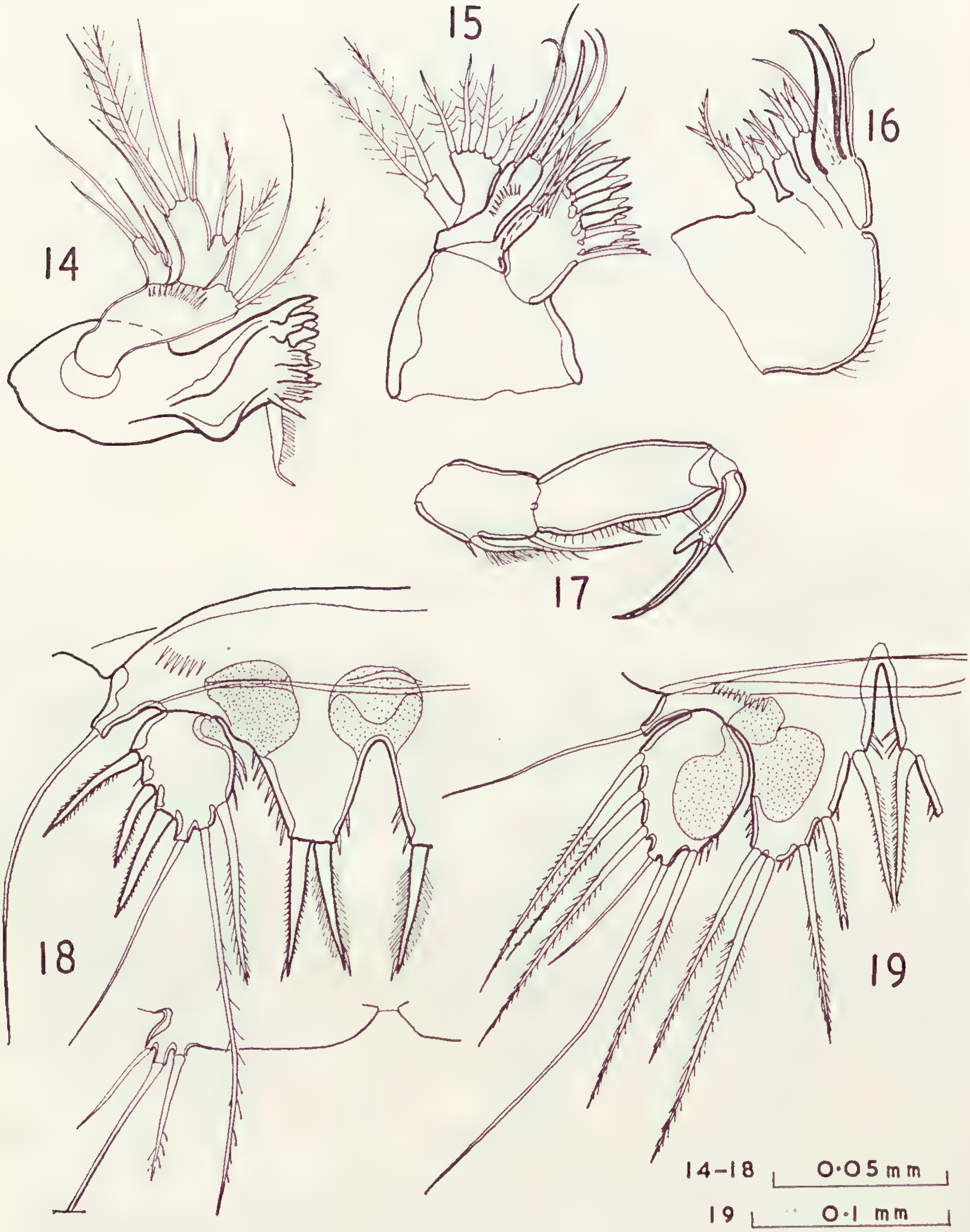
Figs. 8–10 *R. propinqua*, ♂, abdomen. 8, ventral view; 9, lateral view; 10, dorsal view.



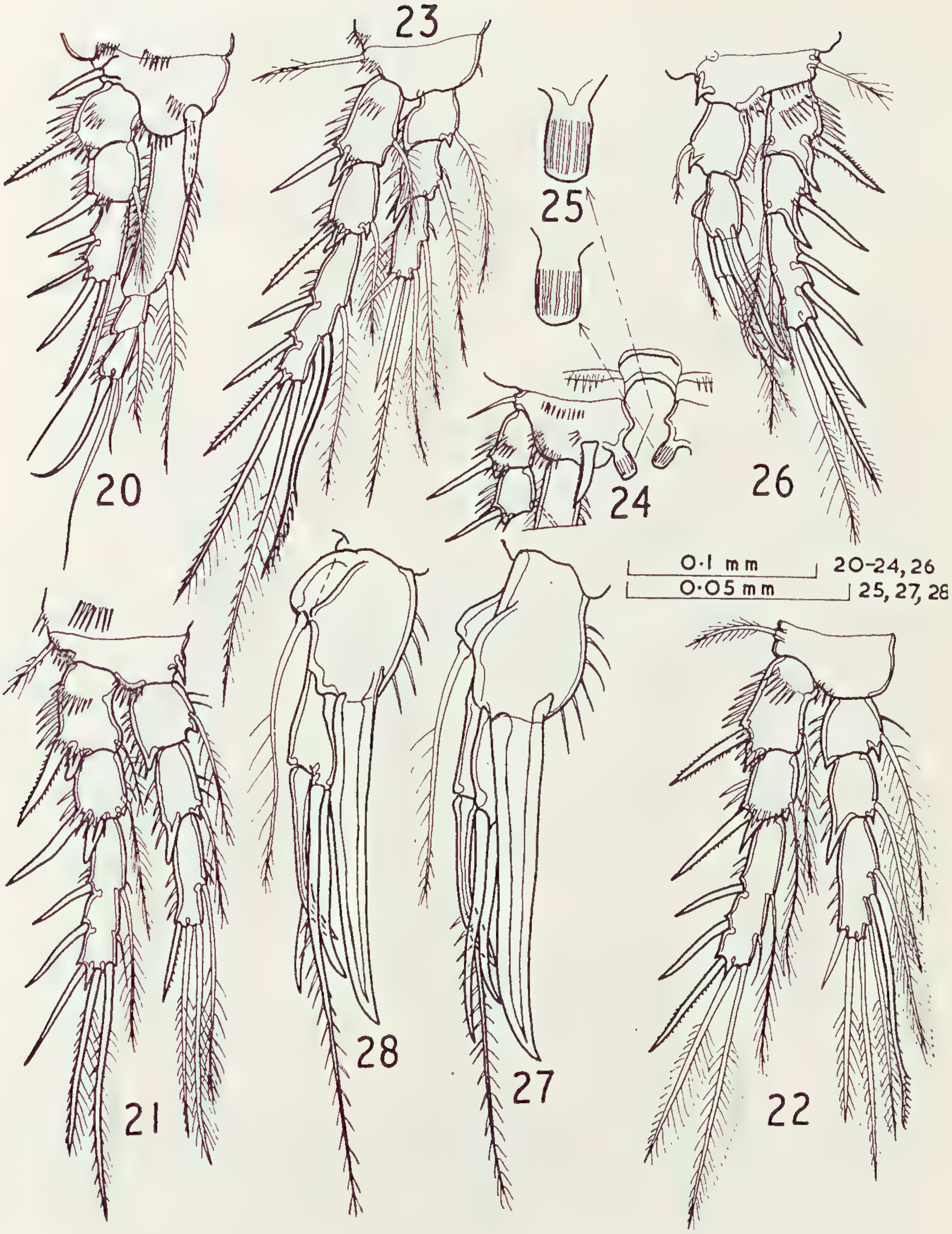
Figs 11–13. *R. propinqua.* 11, R + A1 of ♀; 12, R + A1 of ♂; 13, A2.

Variability

Two females (one of them abnormal) and a male from locality 10B, and another male from locality 13, have been dissected; all four were adult. The abnormality consisted of a setal formula of 121 for P4enp3 on one side only, the other side being normal. P6 in fig. 18 was of the male from locality 13, the other figures all being of the male and the normal female from locality 10B.



Figs 14–19. *R. propinqua.* 14, Md; 15, Mxl; 16, Mx; 17, Mxp; 18, P5 + P6 of ♂; 19, P5 of ♀.



Figs 20–28. *R. propinqua.* 20–23, P1 to P4 of ♀; 24, base of ♂ P1; 25, chitinous knobs on a larger scale; 26, P2 of ♂; 27 and 28, P2enps from both sides of the male, to show details.

Remarks

The original description (Scott, 1894) is of an animal unquestionably close to that from South Australia; however, the segmentation of the antennule is incorrectly shown. As reproduced in Lang (1948), the figures of Scott and of other authors have lost some of their clarity, while conveying also an impression of variability; for either reason (or both) I was inclined to regard the South Australian material as belonging to an undescribed species (see Bayly 1970: 125), until the gap was bridged by the excellent redescription (in Spanish) of *R. propinqua* by Pallares (1970). Assuming that the West African, Argentinian, and South Australian material are conspecific, then *R. propinqua* is probably a circumtropical species; whether more than one species is concealed under this name cannot be stated at present.

Robertsonia barnesi nov. sp. (Figs 29–41).

Description

Female (*holotype*). Body much slenderer than in *R. propinqua*. In dorsal view the prosome is only slightly broader than the abdomen. Rostrum (fig. 31) triangular, with sigmoidally curved sides. Abdomen (fig. 29) with the somitic cuticle (but not the intersomitic membranes) closely and minutely punctate; combs of spines few and small, restricted to the dorsal and lateral aspects of the rear edges of the somites. In fig. 29 the ventral and ventrolateral spinules are shown dotted, owing to their being seen through the substance of the abdomen Genital double-somite with a distinct suture all round. Operculum very hard to see, with a thin, shallowly curved, smooth edge. Furcal ramus broader than long, interramal distance less than the width of a ramus. Numbering from innermost to outermost, the terminal furcal setae run 2431 in order of increasing length (1 singifying the shortest), but 1432 in order of increasing thickness; none is specially modified.

Antennule (fig. 32) with five segments, of which the third bears the aesthetasc; all the setae on it are simple and smooth, except for two on the distal segment, the larger of which bears paired spinules and the other is sparsely bipinnate.

Antenna (fig. 33) with an allobasis from which arises a three-segmented exopod, whose setal formula is 1.0.120.

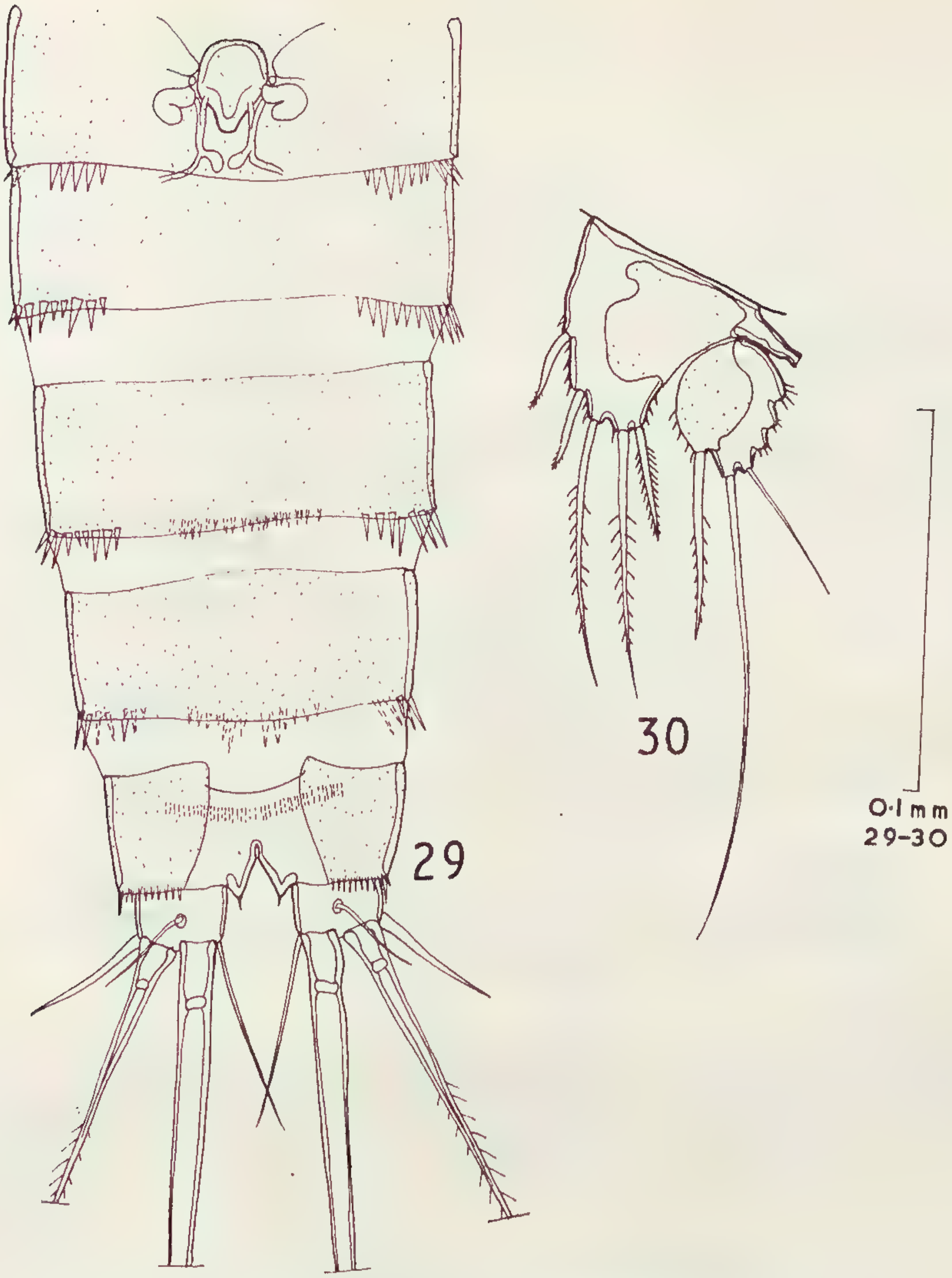
Mandible (fig. 34) with exopod and endopod, each of one segment.

Both maxillules (fig. 35) unfortunately have the distal part folded over, so that I was unable to make out the structure of the rami.

Maxilla (fig. 36) with three endites; maxillipede (fig. 37) not remarkable in any way.

P1 (fig. 38) with both rami three-segmented. The first endopod segment is as long as the whole of the exopod, of whose segments only the middle one has an inner seta. On both sides of the animal the inner seta of the first endopod segment is missing, but its socket is unmistakably present. Swimming legs with both rami three-segmented, the endopods becoming shorter in proportion to their respective exopods towards the tail of the animal. Setal formula as follows:

P2 (fig. 39)		P3 (fig. 40)		P4 (fig. 41)	
exp	enp	exp	enp	exp	enp
1.1.223	1.1.121	1.1.223	1.1.321	1.1.2(?3)23	1.1.221



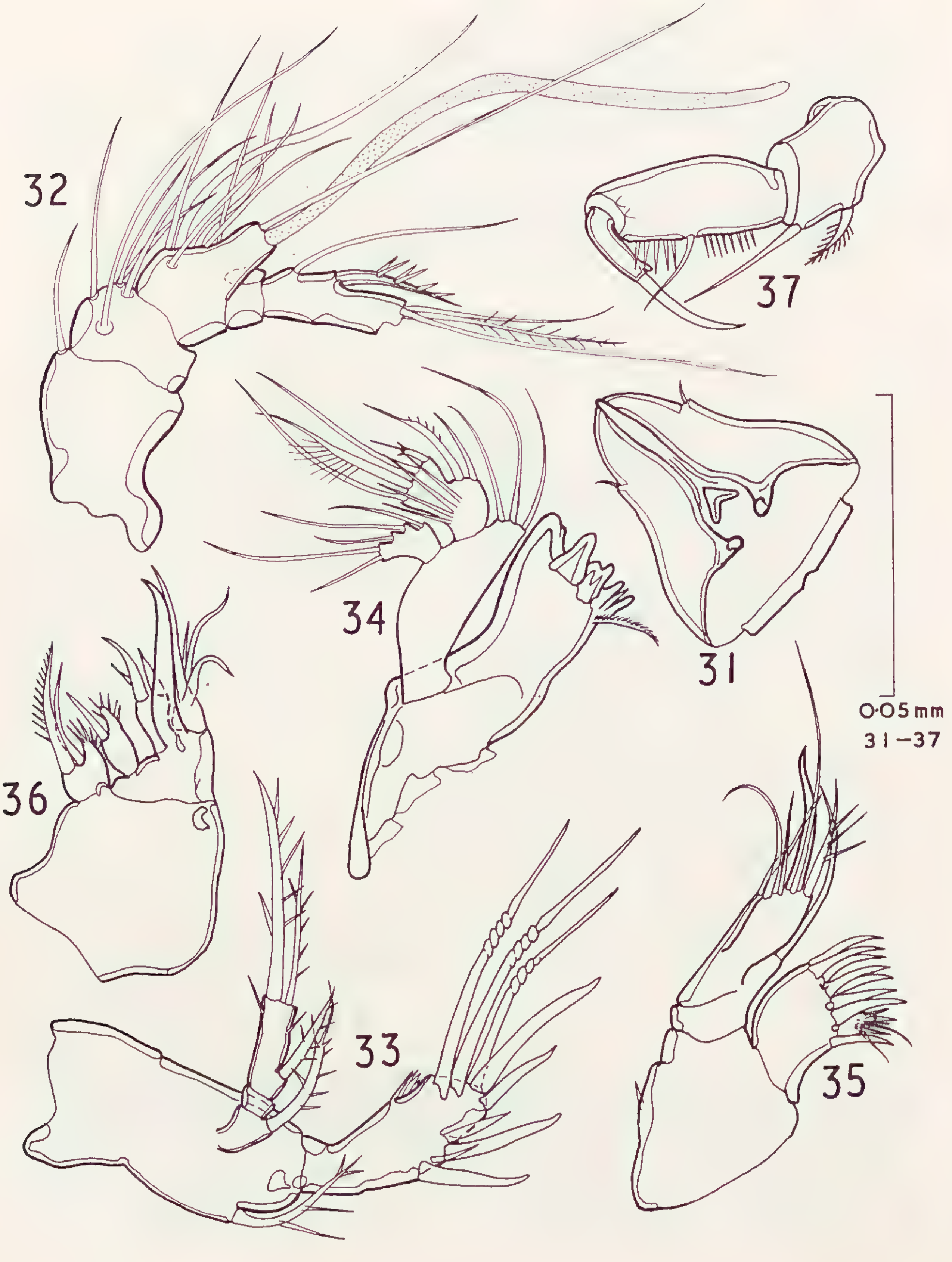
Figs 29, 30. *R. barnesi.* 29, dorsal view of abdomen; 30, P5.

On both sides of the animal the inner edge of P4exp3 has a small kink in the integument, below the two large setae, denoting the possible origin of a third (very much smaller) inner seta; however, I cannot see clearly whether it is in fact present.

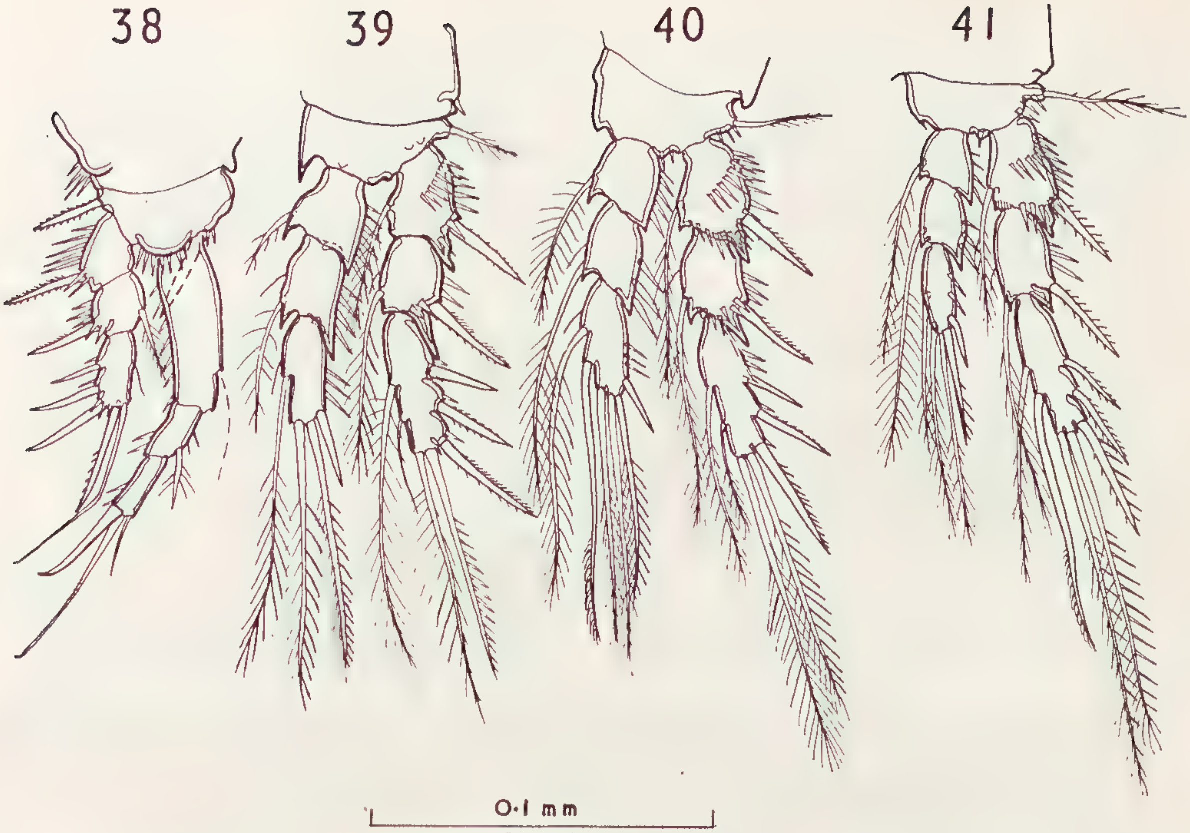
P5 (fig. 30) with discrete rami, each with a large hyaline field; the exopod bears 6 setae, of which the three outermost are missing on both sides of the animal, and the basiendopod has 5 setae.

Male

Unknown



Figs 31–37. *R. barnesi.* 31, R; 32, A1; 33, A2; 34, Md; 35, Mxl; 36, Mx; 37, Mxp.



Figs 38–41. *R. barnesi.* 38, P1 (dashed lines indicate inner basal spine hidden behind enp1, and the missing inner seta of enp1); 39, P2; 40, P3; 41, P4.

Holotype

Female, length 0.7 mm (A M P. 18688), found in a gastropod shell tenanted by the hermit crab *Dardanus megistos* (Herbst), found at L.W.S.T. about 200 yards north of the landing-stage at Green Island, Cairns, Queensland, on 20.7.1970; it was not ovigerous.

Remarks

The very sparse abdominal ornamentation is somewhat unusual in this genus, most of whose species have very spiny abdomens rather like that of *R. propinqua.* I have great pleasure in dedicating this interesting species to Dr J. H. Barnes, M.B.E., physician and ardent amateur marine biologist, of Cairns, to whom I was indebted for information during my stay there.

DISCUSSION

To accommodate *R. barnesi* nov. sp., as well as several others (listed by Bodin, 1967) described since the monograph by Lang (1948), a new key is necessary (see below); no emendation to Lang's generic diagnosis is required.

The genus *Teissierella* Monard (1935) is a synonym of *Robertsonia* Brady (1880), because the type-species *T. celtica* Monard is now regarded as *Robertsonia celtica* (Monard) (see Lang, 1948; Roe, 1958). Sewell's (1940: 287) distinction between these two supposed genera, based on the number of eggbags, has been shown by Lang (1948) to be invalid. Several authors have used the generic name *Teissierella* for certain species which do not belong to *Robertsonia*, and whose status lies outside the scope of this paper.

Revised key to the species of **Robertsonia**

Notes

This is based mainly on the females, but is also applicable to the males, where known; I can find no reason to keep *R. knoxi brasiliensis* apart from typical *R. knoxi*. *R. tenuis* ssp. *kieliensis* Becker (1970) has a clearly bipinnate inner seta on exp1 of P2-P4, all of which lack this seta in normal *R. tenuis*, with which *kieliensis* otherwise entirely agrees.

1. P1enp, first and second segments subequal .... *R. tenuis*
P1,enp1 distinctly longer than enp2 2

2. P2-P4,exp1 with inner seta 3
P2-P4,exp1 without inner seta 5

3. P1,enp1 does not reach to end of exp .... *R. knoxi*
P1,enp1 reaches at least to end of exp 4

4. Abdomen heavily ornamented with numerous rows and groups of spines *R. propinqua*
Abdomen sparsely ornamented, with a few small combs of spines .... *R. barnesi*

5. P3exp3 with one inner seta 8
P3exp3 with two inner setae 11

6. P3enp1 without an inner seta .... *R. flavidula*
P3enp1 with an inner seta 7

7. P2exp3 with one inner seta 8
P2exp3 with two inner setae 9

8. P1,enp1 straight sided, less than four times as long as broad; P1,enp2 and enp3 each much longer than broad; P5exp reaches, in the male to just beyond, and in the female to well beyond, the tip of the benp .... *R. mourei*
P1,enp1 curved so that the outer side is concave, at least five times as long as broad; P1,enp2 and enp3 each much shorter than broad; P5exp reaches, in the male not as far as, and in the female about level with, the tip of the benp .. *R. hamata*

9. P1,enp1 much shorter than exp .... *R. celtica*
P1,enp1 much longer than exp 10

10. A1 with six segments; P1enp1, inner seta inserted at about two thirds the length of the segment; furcal seta not swollen basally .... *R. monardi*
A1 with five segments; P1enp1, inner seta inserts almost at distal end of segment; largest furcal seta with a cylindrical basal swelling .... *R. adduensis*

11. P1,enp1 reaches hardly to end of exp 2 .... *R. diademata*
P1,enp1 reaches at least as far as end of exp3 12

12. P1,enp3 not longer than enp2 .... *R. angolensis*
P1,enp3 about twice as long as enp2 .... *R. irrasa*

ACKNOWLEDGMENTS

I am most grateful to Dr I. A. E. Bayly, Monash University, for sending me the samples containing *R. propinqua;* to Dr J. C. Yaldwyn, Dominion Museum, Wellington, N.Z., for the identification of *Dardanus megistos;* to the Department of Primary Industries, Brisbane, for a permit to collect on Green Island; to Mr and Mrs Miller for their cordial hospitality on the island; and to Dr Barnes for helpful discussions.

REFERENCES

Bayly, I. A. E., 1970. Further studies of some saline lakes of south-east Australia. *Aust. J. mar. Freshwat. Res.* 21: 117–130.

Bayly, I. A. E. & Williams, W. D., 1966. Chemical and biological studies on some saline lakes in south-east Australia. *Aust. J. mar. Freshwat. Res.* 17; 177–228.

Becker, K. H., 1970. Beitrag zur Kenntris der Copepoda Harpacticoidea sublitoraler Weichböden in der Kieler Bucht. *Kieler Meeresforsch.* 26 (1); 56–73.

Bodin, P., 1967. Catalogue des nouveaux copepódes harpacticoides marins. *Mém. Mus. natn. Hist. nat., Paris* (Serie A) 50 (1); 1–76.

Hamond, R., 1969. Methods of studying the copepods. *J. Quekett microsc. Club* 31; 137–149.

Hamond, R., 1971. The Australian species of *Mesochra* (Crustacea: Harpacticoida), with a comprehensive key to the genus. *Aust. J. Zool.* (Suppl. 7); 1–32.

Hamond, R., 1973. The Harpacticoida (Crustacea) of the saline lakes in southeast Australia, with special reference to the Laophontidae. *Rec. Aust. Mus.* 28 (17); 393–420.

Lang, K., 1948. Monographie der Harpacticiden. Hakan Ohlsson, Lund.

Monard, A., 1935. Étude sur la faune des harpacticoides marins de Roscoff. *Trav. Stn biol. Roscoff* 13; 5–89.

Nicholls, A. G., 1945. Marine Copepoda from Western Australia, III. Littoral harpacticoids from Port Denison. *J. Proc. R. Soc. West. Aust.* 29; 1–16.

Noodt, W., 1955. Marine Harpacticoiden (Crust. Cop.) aus dem Marmara Meer. *Istanb. Üniv. Fen Fak. Mecm.* Seri B, 20 (1–2); 49–94.

Pallares, R. E., 1970. Copepodos marinos de la Ria Deseado (Santa Cruz, Argentina); contribucion sistematico-ecologica III. *Physis,* B. Aires 30 (80); 255–282.

Roe, K. M., 1958. The littoral harpacticids of the Dalkey (co. Dublin) area with descriptions of six new species. *Proc. R. Ir. Acad.* 59 (B) 12; 221–255.

Scott, T., 1894. Report on the Entomostraca from the Gulf of Guinea collected by John Rattray, B.Sc. *Trans. Linn. Soc. London Zool.* (2), 6: 1–161.

Sewell, R. B. S., 1940. Copepoda Harpacticoida. *Scient. Rep. John Murray Exped.* 7 (2); 117–382.

ADDENDUM

Since writing the above I have seen the paper by A. Candeias (1959: Contribution to the knowledge of the Harpacticoid (Crustacea, Copepoda) from the littoral of Angola: *Publ. cult. Co. Diam. Ang. Lisboa*, no. 45: 77–104), containing a redescription of *R. propinqua.* The few small differences between Candeias' material and mine, to judge from his excellent drawings, may have been due to ecological differences (reflected in the proportions of certain limb-segments), to rough handling during and after collection, or to difficulties in observation; a much deeper study of the range of variation in different populations of this species is necessary to assess the possible taxonomic importance of these differences.

Broom Cave *Cercartetus:* With Observations on Pygmy Possum Dental Morphology, Variation, and Taxonomy*

NATIONAL MUSEUM OF VICTORIA
12 DEC 1973

By William D. Turnbull

Associate Curator, Fossil Mammals, Field Museum of Natural History, Chicago

and

Frederick R. Schram

Assistant Professor, Zoology Department, Eastern Illinois University, Charleston

Plates 25–31. Figures 1–7. Manuscript received 17th April, 1972.

INTRODUCTION

The murids of the Broom Cave Fauna were dealt with in the first of a series of reports planned to cover the mammals of this Late Pleistocene deposit in the Wombeyan Caves area of New South Wales (Schram & Turnbull, 1970). The fauna is contained in a breccia derived in large part from an accumulation of regurgitated owl pellets. Continuing this series, we now consider the two pygmy possums in the Broom fauna: *Cercartetus nanus* and *Cercartetus lepidus*. Study of these species has involved us with the definition of the genus *Cercartetus* as advanced by Wakefield (1963). Consequently we put forth some observations relating to this delineation along with an analysis of certain dental patterns of the members of this group.

METHODS AND PROCEDURES

Most of the preparation and study techniques we employed are discussed in detail in Schram & Turnbull (1970). We have now completed the preparation of the Fletcher material and therefore this and subsequent studies are based on the complete collection.

---

* This study is based on materials procured by William D. Turnbull and E. L. Lundelius Jr (University of Texas) and prepared by the authors with National Science Foundation assistance (Grants GB975 and GB3729).

We have continued to employ the previously described methods for arriving at an estimate of the maximum and minimum numbers of individuals represented by each sample, viz., the age-spread minimum and the minimal estimate of the maximum. Four age categories were used for the pygmy possums: (a) cusps very sharp and clear, little or no wear; (b) wear of enamel beginning, cusps slightly round, wear facets appearing; (c) wear of enamel well advanced, cusps clearly worn down; (d) tips of cusps almost gone, with dentine exposed and beginning to wear.

All measurements of teeth were made with an ocular micrometer, which with the optics used, permitted direct reading to .038 or .051 mm, with ready interpolation to half of these values per unit. Mean, standard deviation and coefficients of variation were calculated using the IBM 360 computer at Eastern Illinois University.

Extensive examination of Recent material was necessitated in attempting to arrive at an understanding of modern pygmy possum taxonomy. Abbreviations for specimens used in this study are as follows:

AMNH	American Museum of Natural History.
MU	Monash University recent mammal collection.
QVM	Queen Victoria Museum, Launceston, Tasmania.
F	Prefix for fossil collections of Australian Museum.
PM	Some of fossil mammal collections of Field Museum.
FM	Recent mammal collections of Field Museum.
UT	Fossil collections of University of Texas, Austin.

DESCRIPTIONS

(A complete listing of specimens is given in Appendix A.)

Cercartetus nanus

Upper dentition

A single specimen, PM7424, (Plate 26, fig. B) with $\mathrm{I}^{\underline{1}}$ and $\mathrm{I}^{\underline{3}}$ is all we have of the premaxillary bone and dentition. The premaxillary had a high lateral wall. $\mathrm{I}^{\underline{1}}$ is an elongate tooth with a tapering slightly recurved crown that is nearly elliptical in cross-section. It is worn at the tip so that its apex is gone, and the long axis of its elliptical root is parallel to the lateral edge of the bone. $\mathrm{I}^{\underline{3}}$ is triangular in occlusal outline, the anterior and medial sides being vertical and terminating in crests that meet at nearly a right angle. The lateral side is gently curved in both its occlusal outline and in the vertical plane as that side of the crown merges with the other two sides along the two crests.

Nine specimens contribute to our knowledge of the canine and anterior premolar region (F52671, F52720, F52723, F52724, PM6162, PM7426, PM7446, PM7618 and PM17196)—and between them they show a variety of conditions (fig. 1). In no case do we have the canine or anteriormost premolar ($\mathrm{P}^{\underline{1}}$ or $\mathrm{P}^{\underline{2}}$*) preserved, but the alveolus of the canine root is large and oval. Behind this there is always a sizable, diastema before the alveolus (or alveolae) of the anterior of the premolars

---

* There is some disagreement as to which of the anterior two of the four primitive premolars is lost. Since the identity of the anterior-most premolars are debated ($\mathrm{P}\frac{1}{1}$ or $\mathrm{P}\frac{2}{2}$) we shall herein refer to the premolars as $\mathrm{P}\frac{1}{1}$, $\mathrm{P}\frac{3}{3}$, $\mathrm{P}\frac{4}{4}$ without intending to take sides in this controversy.

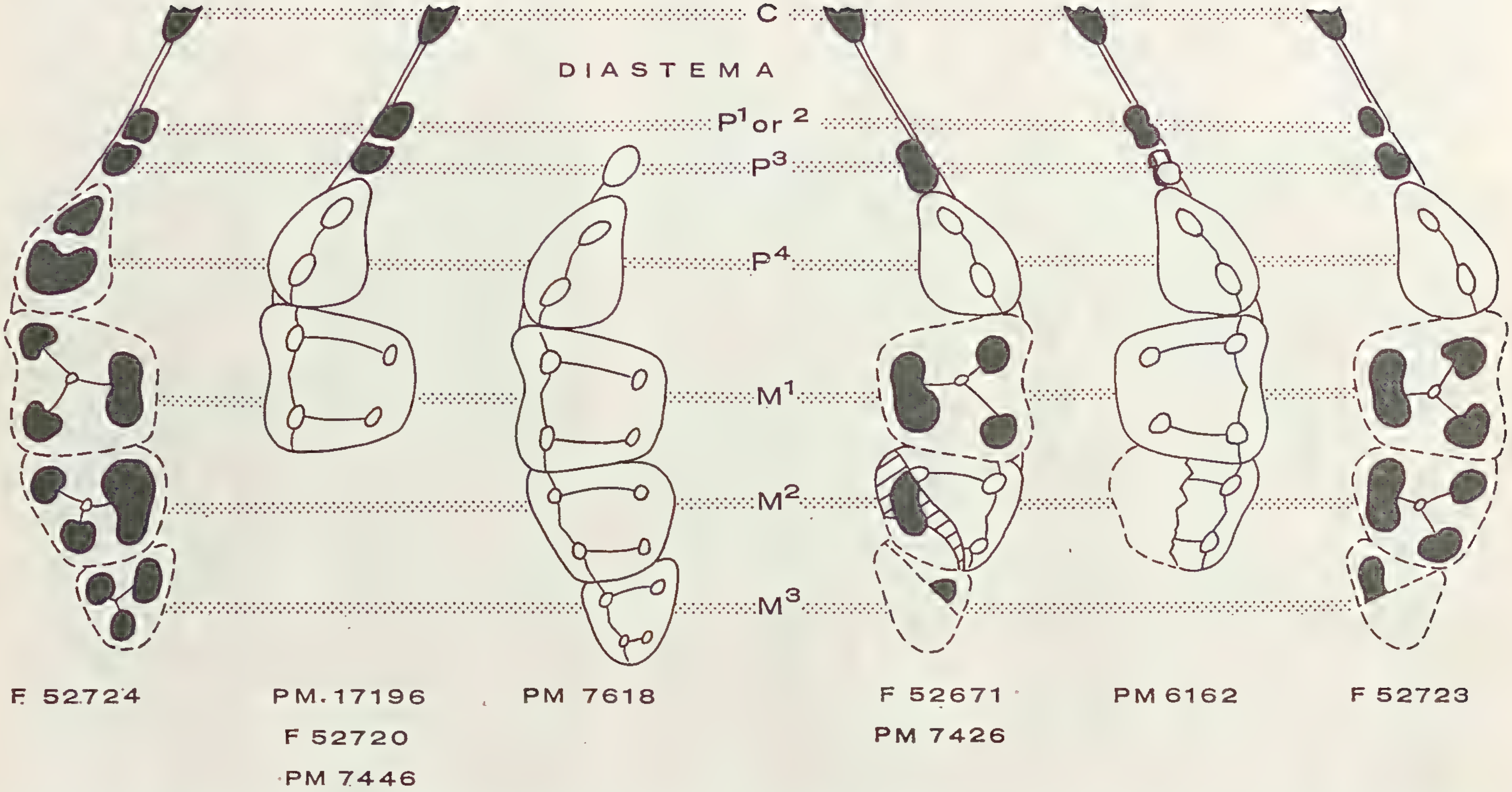


Figure 1. Schematic outline views of the cheek teeth and/or their alveolae (black), showing the variability found in the Broom Cave specimens of *C. nanus*, especially in the anterior premolar region. For tooth crowns, circles and lines represent cusps and crests. For alveolar specimens, circles and lines represent ridges and protuberances of the maxillary bone between the roots beneath the crowns of the teeth.

is encountered. In PM17196 and F52724 there are two large alveolae presumably for two single-rooted teeth comparable to the single-rooted P$^{\underline{3}}$ of PM7618. PM6162 however, has a double-rooted P$^{\underline{3}}$ and the alveolus for its P$^{\underline{1}}$ is bilobed which suggests that this tooth was double-rooted too. In F52671 there is a single hour-glass shaped alveolus anterior to P$^{\underline{4}}$ which might indicate either a double-rooted, large P$^{\underline{3}}$ or two very closely appressed teeth (P$^{\underline{1}}$ and P$^{\underline{3}}$). PM7426 has two large alveoli with a high spire of bone between them not unlike the bone buttress which occurs on two rooted teeth indicating perhaps a relatively large double-rooted P$^{\underline{3}}$ and no P$^{\underline{1}}$.

PM7618 (Pl. 26, fig. A), preserves the most complete tooth row (P$^{\underline{3}}$–M$^{\underline{3}}$). The P$^{\underline{3}}$ is a small oval tooth in occlusal view. Its crown is expanded anteriorly over an even smaller single, peg-like root. The tooth is not as extremely reduced as its counterpart on QVM 1963 : 1 : 14 in which both of the anterior premolars are very tiny single-rooted pegs (Pl. 28, fig. B). The occlusal outline of P$^{\underline{4}}$ has a slightly constricted oval shape. There is a small cuspule immediately behind this constriction on the lingual side near the base of the crown, and sometimes there may be a similar small cuspule behind the constriction on the labial side (PM7446). In addition on PM7426 and PM7446 there is another cuspule at the postero-labial corner of the P$^{\underline{4}}$.

The M$^{\underline{1}}$ is a nearly square, low crowned tooth composed of the four major cusps. The paracone and metacone are larger and stand higher than the protocone and hypocone which are low and somewhat crescentic. The paracone and metacone are crested antero-posteriorly on all the upper molars. These crests abut one another so that there is a continuous arc from the anterior edge of P$^{\underline{4}}$ to the posterior edge of M$^{\underline{3}}$. Three weak labial cingula are developed antero-lateral to the paracone, postero-lateral to the metacone, and lateral to the crest connecting the two cusps. Occasionally a broad lateral cingular shelf may develop as in PM17196 (Pl. 26, fig. D). The distance between the paracone and metacone is greater than that between the protocone and hypocone but a line between the labial cusps is roughly parallel to one between the two lingual cusps. In addition, the labial length of the tooth crown is somewhat greater than the lingual length.

The M$^{\underline{2}}$ is wider anteriorly than posteriorly and the distance between the protocone and paracone is greater than that between the hypocone and metacone. The protocone is the largest cusp in occlusal view, but it is not as high as the paracone and metacone which are about subequal. The hypocone is the smallest cusp. The distinct anterior cingulum is best developed near the paracone at the antero-labial corner of the tooth. It is continuous with an antero-labially directed ridge from the protocone. There is a posterior cingular shelf on the rear of the tooth between the metacone and hypocone. In both M$^{\underline{1}}$ and M$^{\underline{2}}$ there are weakly and somewhat variably, developed transverse lophs (protoloph and metaloph). These lophs usually are stronger on M$^{\underline{2}}$ (F52670) than on M$^{\underline{1}}$ (Pl. 26, fig. E).

The M$^{\underline{3}}$ is triangular in shape. It is broad across the anterior edge where it contacts the M$^{\underline{2}}$. The metacone and hypocone are very reduced and lie close to each other. The protocone is the largest of the cusps in occlusal view but the paracone is the highest. Between the main cusps there is an elongate oval basin whose axis lies lateral to the center of the tooth.

The anterior buttress of the zygomatic arch comes off from an area lateral to the posterior third of M$^{\underline{1}}$ and the anterior third of M$^{\underline{2}}$, and diverges posteriorly at about 45°. The infraorbital foramen lies approximately over the posterior root of the P$^{\underline{4}}$.

Lower dentition

There are a number of specimens which preserve a considerable portion of the mandible but no ramus is complete. Several specimens preserve the coronoid process and two preserve the angle. No one specimen has an entire tooth row, nor do any have a complete condyle.

The elongate, procumbent $I_{\bar{1}}$ is elliptical in cross-section at the point where it protrudes from its alveolus. It tends to flatten at its tip and is slightly twisted, but in none of these specimens is the $I_{\bar{1}}$ spatulate. The weak cresting on the ventral edge of the medial surface of this incisor tends to be eliminated with wear. Wear on this tooth seems to be excessive and peculiar: F52619 (Pl. 27, fig. C) had the enamel breached all along its length (though the tip is broken off) and PM16981 has its pulp cavity exposed at the tip (Pl. 26, fig. F). No $I_{\bar{2}}$ is preserved in our material. But five out of seven specimens in which this region of the jaw is preserved indicate it was a small, single-rooted tooth procumbent on the larger incisor. The $P_{\bar{1}}$ and $P_{\bar{3}}$ are small and about the same size. They are cuspless and double-rooted with low, oval, pillow-like crowns that protrude in all directions over the roots. PM16981 shows these premolars and the alveolus of the $I_{\bar{2}}$ to the best advantage (Pl. 26, fig. F).

The double-rooted $P_{\bar{4}}$ is a large tooth with a single, central, high cusp. It is nearer in size to the molars than to the tiny premolars (Pl. 26, figs. F & G; Pl. 27, figs. B, C, D & E). There is a weak anterior crest from the apex of the cusp to the anterior edge of the base of the crown. There is a slightly stronger posterior crest that proceeds from the apex of the cusp nearly to the back edge of the crown where it curves lingually. The central cusp is usually perpendicular, but may be slightly bent anteriorly or posteriorly. In occlusal view a $P_{\bar{4}}$ is typically broadly rounded anteriorly while posteriorly the oval form is blunted at a slight angle on the postero-lingual corner. It is usually longer than wide but occasionally may be as broad posteriorly as it is long.

The $M_{\bar{1}}$ is quite distinctive, being nearly rectangular in occlusal view (Pl. 26, fig. G). It is slightly narrower in front than behind in the fossils, but the Recent specimen (QVM 1963 : 1 : 14) has an $M_{\bar{1}}$ which is more subtriangular in occlusal view (Pl. 28, fig. A). The $M_{\bar{1}}$ has three triangularly placed cusps; the anterior one is presumably a metaconid, the posterior pair are the hypoconid and entoconid. The three cusps are connected by ridges so that an elongate triangular basin is formed in the center of the tooth. The posterior ridge of the metaconid and the anterior ridge of the entoconid meet at the lingual edge of the valley between these cusps. There is a strong crest extending forward from the metaconid. This is aligned with the crest of the $P_{\bar{4}}$ with which it forms a nearly continuous blade. The hypoconid is broadly crescentic as a result of its cresting. Its anterior crest progressively diminishes as it runs antero-lingually and approaches the metaconid. The posterior crest proceeds postero-lingually and joins the posterior crest of the entoconid at the postero-labial corner of the tooth. In some specimens there is a slight bulge or inflection along the posterior crest from the metaconid which may be interpreted as a vestige of a metastylid. Similarly on the anterior crest of the metaconid there is occasionally an irregularity which could be interpreted as a vestige of a paraconid. The region where a protoconid would lie is a broad, steeply inclined, curving surface without indication of a cusp, (so, in some respects, the trigonid region of the Broom Cave fossils is more primitive than that of the recent specimen (QVM 1963 : 1 : 14) which does not have this protoconid bulge or the other features mentioned above).

There is little cingular development; what there is lies along the anterior edge of the tooth on both its lingual and labial sides. There cingula rise steeply to terminate at the anteriormost point of the anterior crest of the metaconid. There is typically a weak embayment on the anterior face of the tooth to accommodate the posterior face of the $P_{\overline{4}}$.

$M_{\overline{2}}$ and $M_{\overline{3}}$ are nearly rectangular, elongate teeth, each with a similar dental morphology. The most notable difference is size, $M_{\overline{3}}$ being slightly smaller (Pl. 27, figs. D & E). In both teeth the protoconid and hypoconid are low cusps. In each the protoconid is ridged anteriorly and posteriorly from its apex, the anterior ridge running to the antero-labial edge of the tooth and the posterior ridge proceeding posteriorly and somewhat lingually, meeting the anterior crest of the hypoconid. Each hypoconid has a nearly lingually directed posterior crest which lies along the back edge of the tooth to join the posterior crest of the entoconid. The metaconids and entoconids have apices which lie far to the lingual sides of the teeth. A crest runs from the apex of each of these cusps towards the other to meet in the valley between them. A second metaconid crest, the anterior one, does not always reach the apex of that cusp. It extends to the antero-lingual corner of the tooth and becomes contiguous with the anterior cingulum crossing the front of the tooth to join with the anterior crest of the protoconid. The crests of all these cusps thus delimit a rather sinuous central basin whose undulating form is enhanced by subsiding crests that lead inward for a short distance from each cusp. There is considerable variability in the length/width ratios of these teeth: $M_{\overline{3}}$ is always longer than wide and slightly wider in front than behind; $M_{\overline{2}}$ is usually longer than wide and parallel sided, but can occasionally be almost square. An antero-labial cingulum rises to meet the anterior crest of the protoconid where that crest joins the main cingulum across the front of the tooth. There is no $M_{\overline{4}}$.

The masseteric fossa is variably developed. It is usually quite deep and the surrounding crests are pronounced (Pl. 27, figs. A, B, & E), especially that leading to the tip of the coronoid process. The angulation of the antero-ventral corner of the fossa and the extent to which it extends onto the ramus is variable (PM16980 and F52618). The angular process is stout, tapering, weakly inflected, bluntly rounded in front, flattened on its ventro-lateral surface, and concave on its dorso-medial surface behind the ridged anterior edge. The inferior dental foramen (mental foramen) is single and usually lies beneath the anterior root of $P_{\overline{4}}$ but may be situated slightly anterior to this. Nearby and in front of it are a few small nutrient foramina which are variable in their occurrence.

If the single Recent specimen we have studied is indeed typical, then it is our impression that the Broom Cave *Cercartetus nanus* is somewhat different. It is undoubtedly still the same species, but the variations noted above in the $M_{\overline{1}}$ and the upper premolar series could be considered indicative of primitiveness, while most other variations argue neither for a more primitive nor a more advanced condition.

Cercartetus lepidus

Upper dentition

The two edentulous maxillary fragments of *C. lepidus* preserve approximately the same structures. In both, the anterior buttress of the zygomatic arch extends from the area lateral to $M^{\underline{1}}$ and $M^{\underline{2}}$. Specimen F52768 has the greatest number of alveoli, preserving about half of that of the canine and those of all the cheek teeth (Pl. 30, fig. C). Behind the canine there is a diastema posterior to which lie four aligned equal alveoli for the paired roots of the first two premolars, followed by two large alveoli for the $P^{\underline{4}}$. The triangularly placed alveoli of $M^{\underline{1}}$ through $M^{\underline{3}}$ form a rather uniform decreasing size gradient. Alveoli of $M^{\underline{4}}$ are variable: in F52768 the labial ones are very reduced and combine with the lingual one, whereas in PM17244, the alveoli are all distinct though reduced (Pl. 30, fig. A).

The $P^{\underline{4}}$ has two subequal fused cusps which are merged for at least $\frac{2}{3}$ of their height. They appear as distinct entities only at their apices. In PM7578 the posterior one is slightly larger than its twin. The $P^{\underline{4}}$s are broad posteriorly and narrow anteriorly with a weak axial crest. In PM 17246 the anterior root is exceptional in that it extends forward quite markedly (Pl. 25, fig. B).

The $M^{\underline{1}}$ is longer on the labial side than on the lingual. The paracone and metacone are relatively large cusps connected by a ridge that runs the full length of the labial side. The protocone and hypocone are connected by a weak crest. They are subequal but are much smaller cusps, and are closer together than are paracone and metacone (Pl. 30, fig. B). There are additional crests from the protocone (running antero-labially) and from the hypocone (running postero-labially). Both these laterally directed crests extend as cingular ridges to the longitudinal crest of the labial cusps. There is a weak suggestion of a connection between the hypocone and metacone but basically the cusps sit on the perimeter of the crowns and are separated by a broad open valley. There is no distinct parastyle or metastyle but there is a weak bulging in the appropriate position for each.

The $M^{\underline{2}}$ is decidedly wider anteriorly than posteriorly. The paracone is the highest and largest cusp, followed in size by the protocone, metacone and hypocone. The cresting of these cusps is essentially as in $M^{\underline{1}}$. Usually there is no stylar shelf development beyond a weak cingular bulge at the base of the crown (Eg. F52777; Pl. 30, fig. D), but occasionally a rather decided cingular shelf is developed. This shelf is greatest on F52769 (Pl. 30, fig. F). A comparable situation exists in the AMNH series of *C. caudatus;* here too this may be a matter of individual variation.

The $M^{\underline{3}}$ is essentially a smaller version of the $M^{\underline{2}}$ with the exception of having a less decided hypocone which is little more than a cingular bulge (Pl. 30, fig. E). We found none of the tiny $M^{\underline{4}}$s of this species in our sample, however, as noted above, the edentulous maxillae do have alveoli for the $M^{\underline{4}}$.

Lower dentition

As is the case with the maxillary fragments, specimens of the mandibles have lost most, if not all of their teeth (Pl. 30, fig. G; Pl. 31, fig. A). The alveolus for the $I_{\overline{2}}$ is single and larger than any of the four alveoli of the first two premolars that follow it. The alveoli for $P_{\overline{4}}$ through $M_{\overline{2}}$ are large, those of $M_{\overline{3}}$ are noticably smaller, and those of $M_{\overline{4}}$ are minute. The condyle is flat and spatulate, the masseteric fossa is broad, and the coronoid process is weak (Pl. 31, fig. A). The angular process is well developed and inflected.

The $I_{\overline{1}}$ (F52767) is gently curved and tapered with a ventro-median ridge (Pl. 31, fig. B). It is not very spatulate but retains a subtriangular cross section throughout its length. The broken incisor in F52780 is less ridged than F52767.

The $P_{\overline{4}}$ in jaw PM6163 (one of the few with a tooth in place) is blade-like with two high compressed cusps with very little space between them, (Pl. 30, fig. G). The tooth is broader posteriorly than anteriorly. There is an incipient cuspule on the posterior ridge of the posterior main cusp. A more typical condition, however, has the $P_{\overline{4}}$ with a less blade-like condition and no incipient cuspule behind the posterior cusp.

The $M_{\overline{1}}$ has an elongate, triangular outline in occlusal view, with the widest portion across the talonid (Pl. 31, fig. C). Its protoconid, metaconid, hypoconid and entoconid are well developed. The protoconid and metaconid are well separated, the latter is crested on its posterior side. The protoconid and hypoconid have strong, oblique anterior crests and weaker posterior crests. The posterior crests proceed in a postero-lingual direction, that from the hypoconid arcs across the posterior face of the tooth as a cingulum. There is merely the faintest suggestion of an anterior cingulum antero-labial to the protoconid. A stronger cingular ridge runs along the anterior face of the tooth to join the anterior crest from the metaconid at approximately the position that the weak labial cingulum joins the crest. It is possible that this junction represents a vestige of the paraconid. The hypoconid is the largest of the cusps. The protoconid and entoconid are about equal and slightly larger than the metaconid. The talonid has an elongate open valley.

The $M_{\overline{2}}$ and $M_{\overline{3}}$ have essentially the same form. They are rectangular teeth in occlusal view though slightly constricted across the middle (Pl. 31, figs. D & E). In both these teeth, the hypoconid is the largest cusp, the protoconid and entoconid are subequal, and the metaconid is the smallest. Each of the cusps tends to be concave on the side toward the center of the tooth, so that an extensive elongate valley runs the length of the tooth. It is broader and more developed in the talonid than in the trigonid, yet both areas form a connected, open basin. The labial cusps carry anterior and posterior crests as they did in $M_{\overline{1}}$. The $M_{\overline{2}}$ is slightly wider posteriorly while the $M_{\overline{3}}$ is wider anteriorly (Pl. 31, fig. F). There are no $M_{\overline{4}}$s in our sample though there are alveoli for this tooth in all the mandibles.

The morphology of the fossils of *C. lepidus* compares favorably with that observed in the small series of Recent individuals from the Queen Victoria Museum. Stereo-photos of the upper and lower teeth of a Recent specimen from that series (QVM 1964 : 1 : 249) are offered for comparison in Plate 29, figures A–B.

Statistical data for both species of Broom Cave *Cercartetus* are given in Tables 1 and 2.

RESULTS AND DISCUSSION

Relative abundance

The pygmy possums *Cercartetus nanus* and *Cercartetus lepidus*, were both noted by Ride (1960). His relative abundances were based on a very limited sample. He found *C. nanus* specimens to be five times more abundant than *C. lepidus*, and in number of individuals the ratio was 3 : 1. We find the ratios in our much larger sample to be 10 : 1 when comparing total numbers of teeth, 6 : 1 with minimum number of individuals, and 7 : 1 with the more realistic mode of assessing population (see Table 3 and Appendix B). Based on our experience, it appears that Ride was extremely lucky in getting enough *C. lepidus* to get the small ratios he got. *Cercartetus nanus* is the most common of all marsupials in the fauna while *Cercartetus lepidus* is relatively rare. The apparent scarcity of *C. lepidus* may be due in part to the small and fragile nature of the material. Practically no teeth were found in jaws or maxillaries, having fallen out either during the diagenesis of the deposit or (undoubtedly) during our acid preparation of the breccia.

Examination of the graphs of the age group assignments of the Broom Cave pygmy possums shows an array of distorted bell-shaped curves (Fig. 2, left and middle). These curves are reminiscent of those representing the population distribution of the murids of this fauna. The rat distribution conformed fairly closely to a normal curve, there being a marked shortage of individuals at the young half of the array. In the murid case it was suggested that if, as presumed, the owls

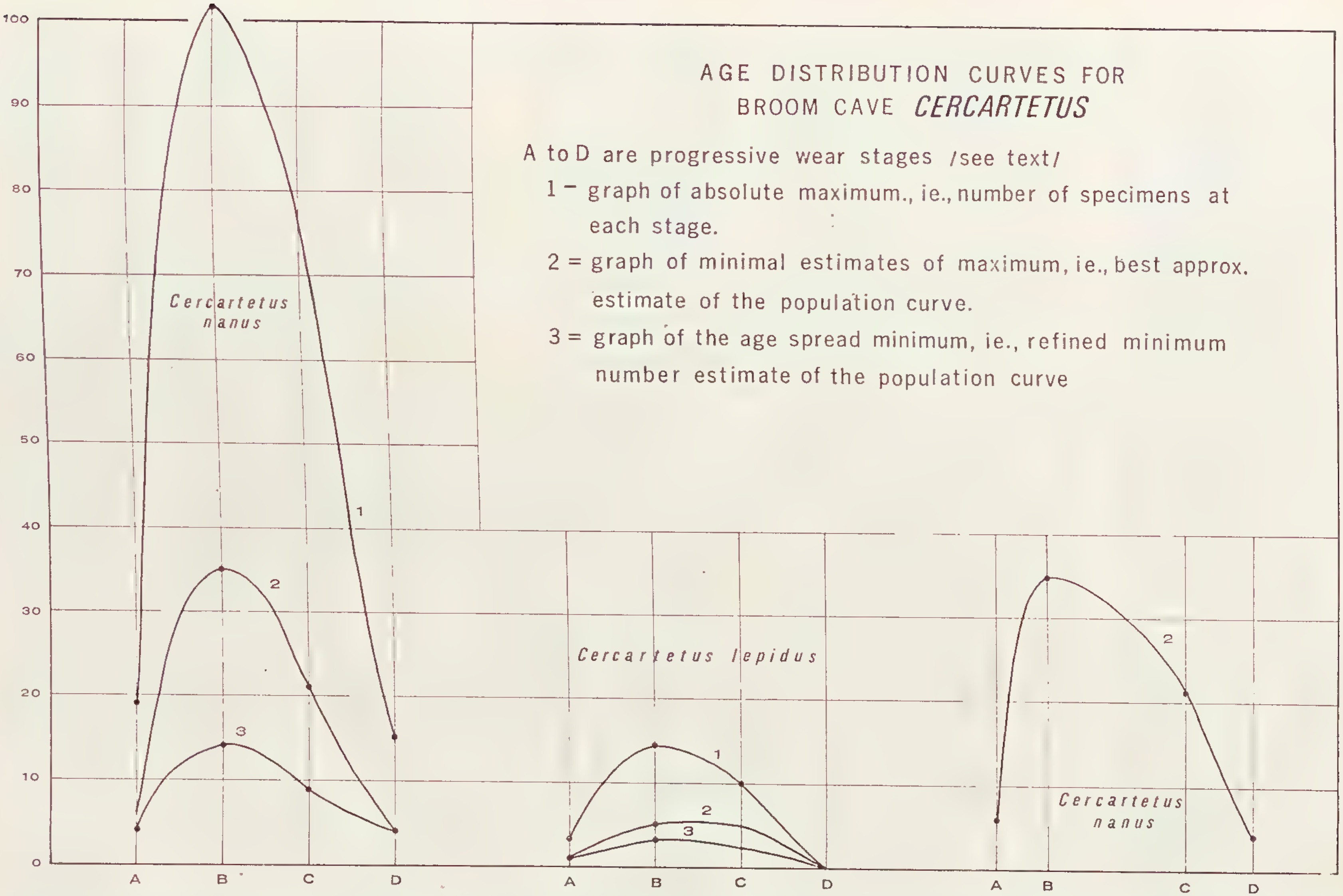


Figure 2. Curves of the age distribution of the Broom Cave *Cercartetus* species. The two sets shown left and center are plotted against four equally spaced lines that represent progressive wear stages A through D. The right curve for *C. nanus* (No. 2) is plotted against the same wear stages. But here the spacing between the stages is varied so as to be more in accord with the time needed to achieve the degree of wear appropriate to each wear stage.

were essentially indiscriminate in their predation, one would expect a distribution more like a survivorship curve than a bell curve. The pygmy possum curves, are however, different from the murid curves. The pygmy possum distribution is definitely skewed toward the younger forms. Indeed the major portion of the curve is basically one of survivorship. Only the very youngest stage as defined by us is low. In the murids, the numerical deficiency of young rodents was explained by assuming many of the young rats were protected from predation in the nest. But since marsupial mothers carry their young with them, the apparent low number of young is initially puzzling. Clearly the explanation applied to the murids cannot be extended to the pygmy possums. Where then have all the young pygmy possums gone?

A possible solution to this problem may lie in the life style and breeding habits of the pygmy possums. These animals live in bush and forest situations. In such confined environments they would tend to be protected from owl predation. Troughton (1957) says that pygmy possums *C. concinnus* (and presumably the other species of pygmy possums) breed twice a year, summer and winter. Those young born in winter would be protected for the rest of that season and upon emerging from hibernation with their mother would be at an advanced age. Those born in the summer and not having fallen prey would then hibernate and emerge at a more advanced age. In addition, the males might tend to be more far ranging in foraging habits, females possibly staying close to the nest. The males would be more likely then to be captured. The curves would then represent a sample subject to seasonal influxes of pygmy possums into the environment and perhaps with more males than females.

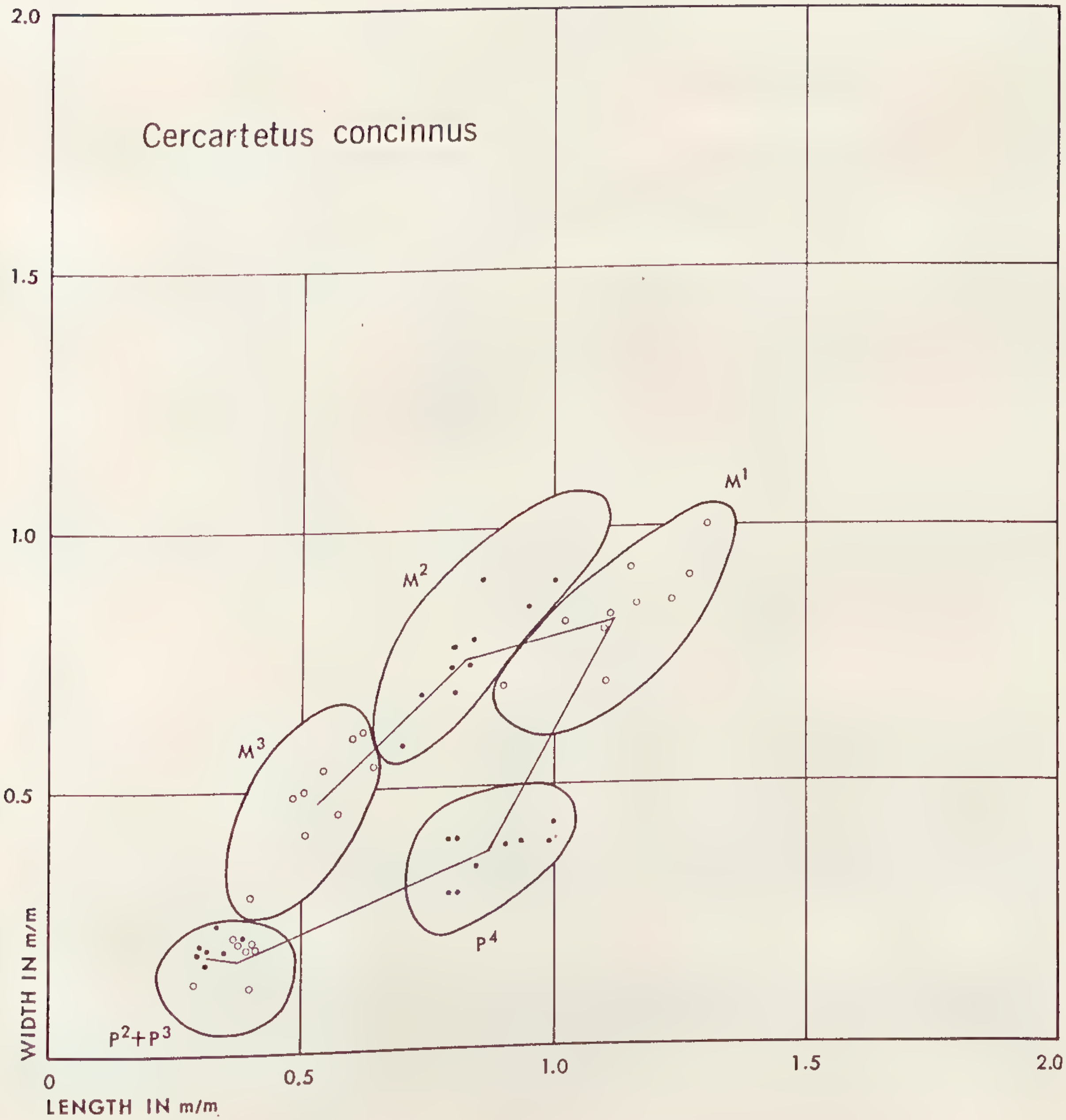
The discrepancy in the numbers of young individuals may in part also be an artifact due to our age assignments based on tooth wear. It is sometimes difficult to decide on an age for a specific tooth. Ages A and B are probably not too far separated in time in the animals life cycle. There are all sorts of gradations between ages B and C. Consequently, instead of drawing a curve based on four equally spaced points, the first two points (ages A and B) should be perhaps rather closely aligned, the second and third points (ages B and C) should be quite far apart since they represent a substantial portion of the life cycle, and the fourth point (age D) should follow soon on the third (Fig. 2, right).

Dental patterns and taxonomy

Iredale and Troughton (1934) and Troughton (1957) recognized two genera of pygmy possums: *Cercartetus*, with two species, *C. nanus* and *C. concinnus;* and *Eudromicia*, with three species, *E. caudata*, *E. lepida* and *E. macrura*. Wakefield (1963) reviewed the taxonomy of these animals and placed all species in *Cercartetus* and made *macrura* a subspecies of *caudata* (which on the basis of dental morphology and measurements appears to be correct). He claimed the differences among the species were insufficient to warrant their separation into separate genera. We have re-examined in detail all the species in question paying especial attention to dental characteristics. Our conclusions, at variance with Wakefield, illustrate a continuing palaeozoological problem; attempting to reconcile taxonomic conclusions based on gross external observations with detailed dental and/or skeletal studies.

We have undertaken an examination of the species in question utilizing any materials we could borrow and study, both fossil and Recent. The material (including items from the collections of the Field Museum and specimens borrowed from the Archbold Collection of the American Museum, The University of Texas, The Australian Museum, Sydney, and the Queen Victoria Museum in Launceton, Tasmania) was limited but we believe sufficient to give us a very clear idea as to the dental variation which occurs in the pygmy possums.

Figure 3. Figures 3–6 are each bivariate graphs resulting from plotting length (abscissa) and width (ordinate) measurements of upper cheek teeth for each of the species of *Cercartetus*. With the molars, anterior width was always used, while with premolars, where often the crown is not bilobate or rectangular, either maximum width or anterior width was used according to which measure was appropriate. In each case the resulting cluster of points is contained within a hand-drawn cloud, and the means for each tooth are connected in sequence by a line to provide the distinctive pattern of each species. Figure 3 is below. Figures 4, 5, and 6 are on the next three pages.



One of the lines of investigation we found most useful was comparative analysis of tooth size patterns resulting from bivariant plots of cheek teeth series. This involves plotting lengths and widths of teeth and observing changes in relative sizes from tooth to tooth along a series, within and between species.

Analysis of the four species (of Wakefield) reveals distinct differences among all of them as well as certain similarities (Figs. 3–6). We confine our discussion here to the upper tooth series for which the differences are most striking. *C. concinnus* has the anterior two premolars peglike and small. P^{4} is small and elongate with a typical primitive premolar pattern of two roots and a crown with a single central cusp. M^{1} is somewhat elongate and small; M^{2} is smaller than M^{1} and nearly square; M^{3} is quite small and square; M^{4} is absent.

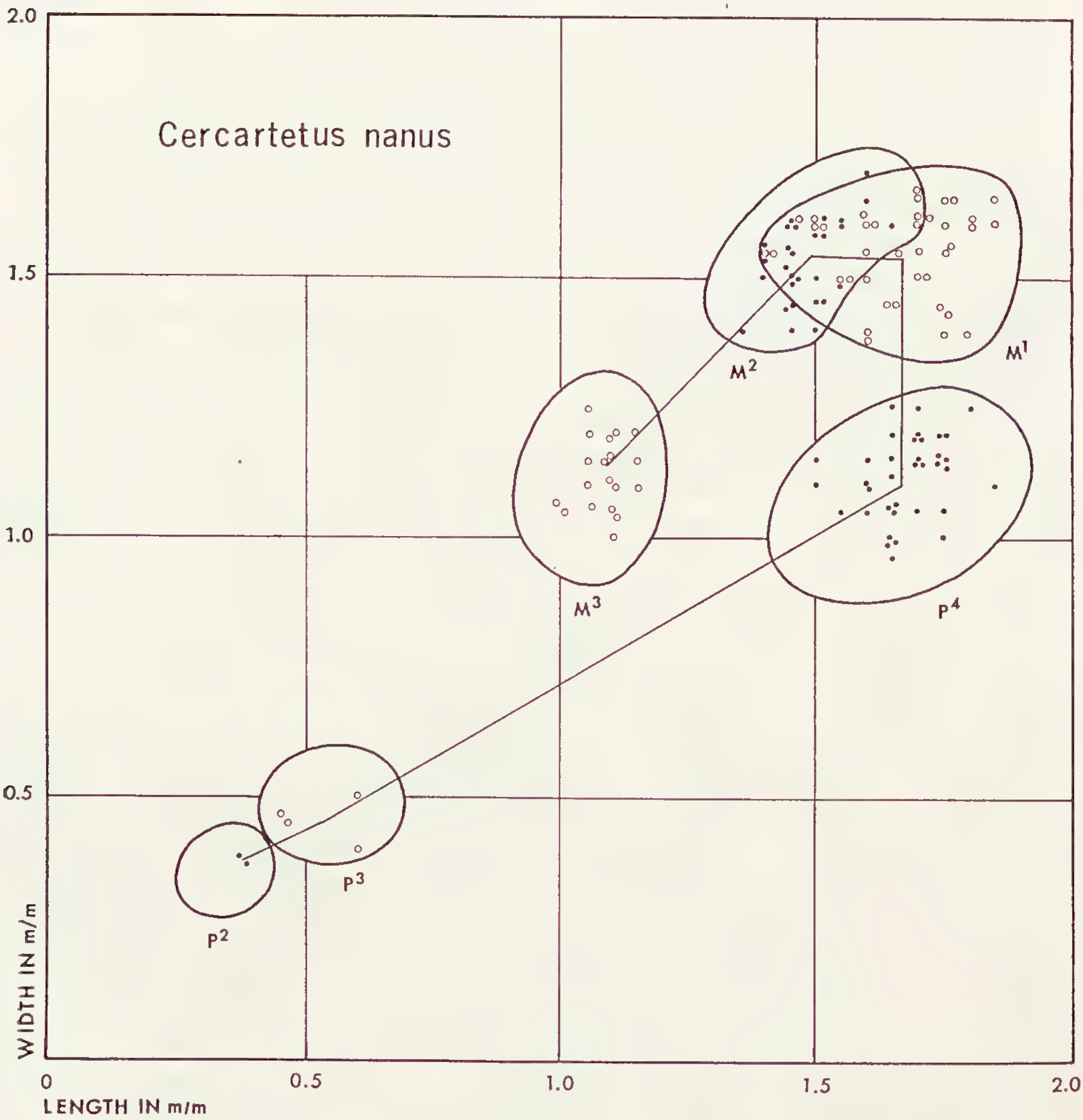


Figure 4

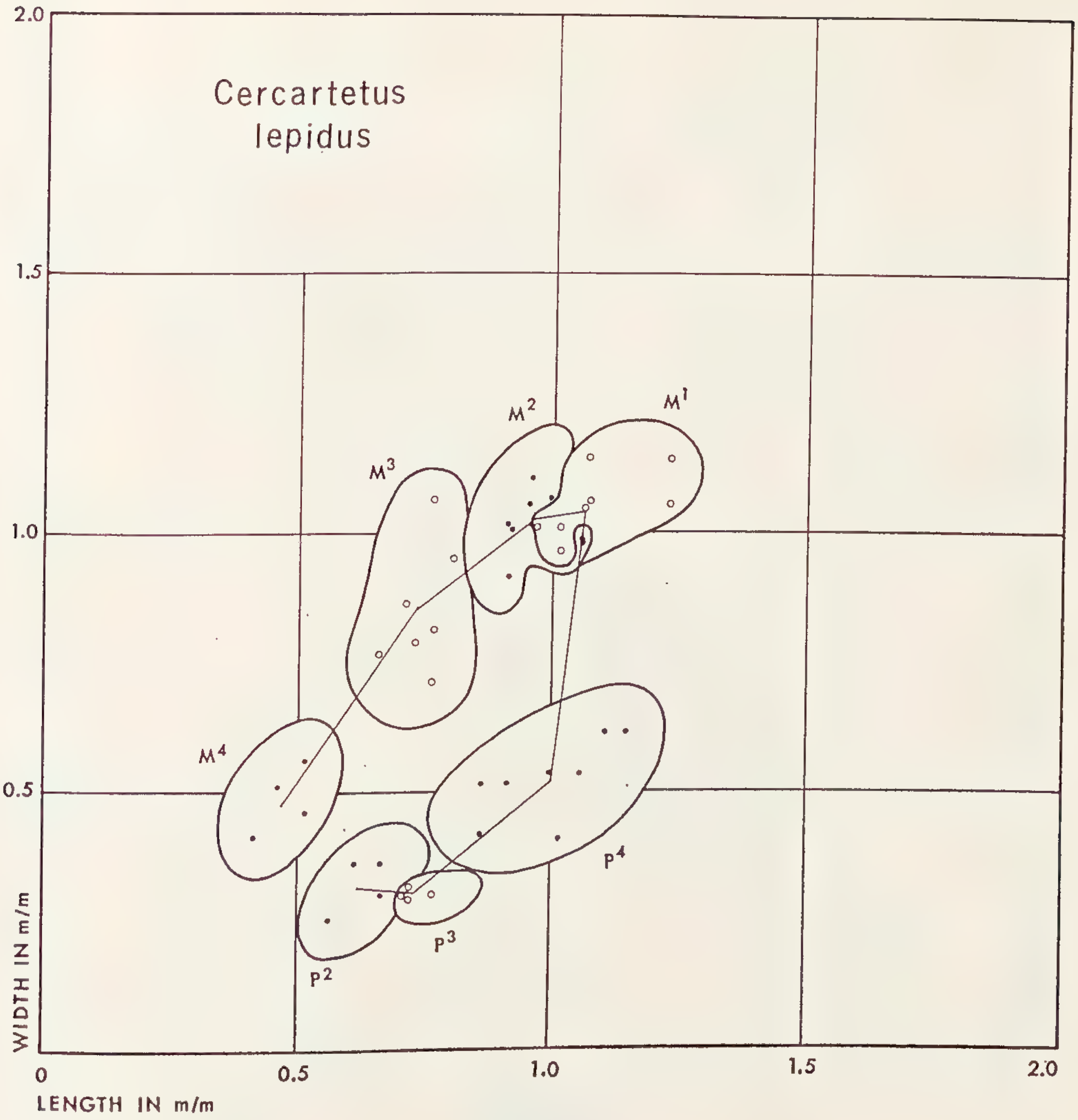


Figure 5

C. nanus has two very small peglike anterior premolars, and P^{4} is quite large both in length and width (nearly the size of M^{1}) with two prominent distinct cusps. M^{1} is a large square tooth, M^{2} proportioned nearly as M^{1}, except somewhat shorter. M^{3} is smaller than M^{1} or M^{2} and its length and width dimensions are nearly equal. M^{4} is absent.

C. lepidus also has the anterior two premolars peglike and small. P^{4} is small and elongate with a small set of twinned cusps. M^{1} and M^{2} are small, square and nearly the same size. M^{3} is similarly proportioned but smaller yet and M^{4} is very reduced (shorter than any of the premolars).

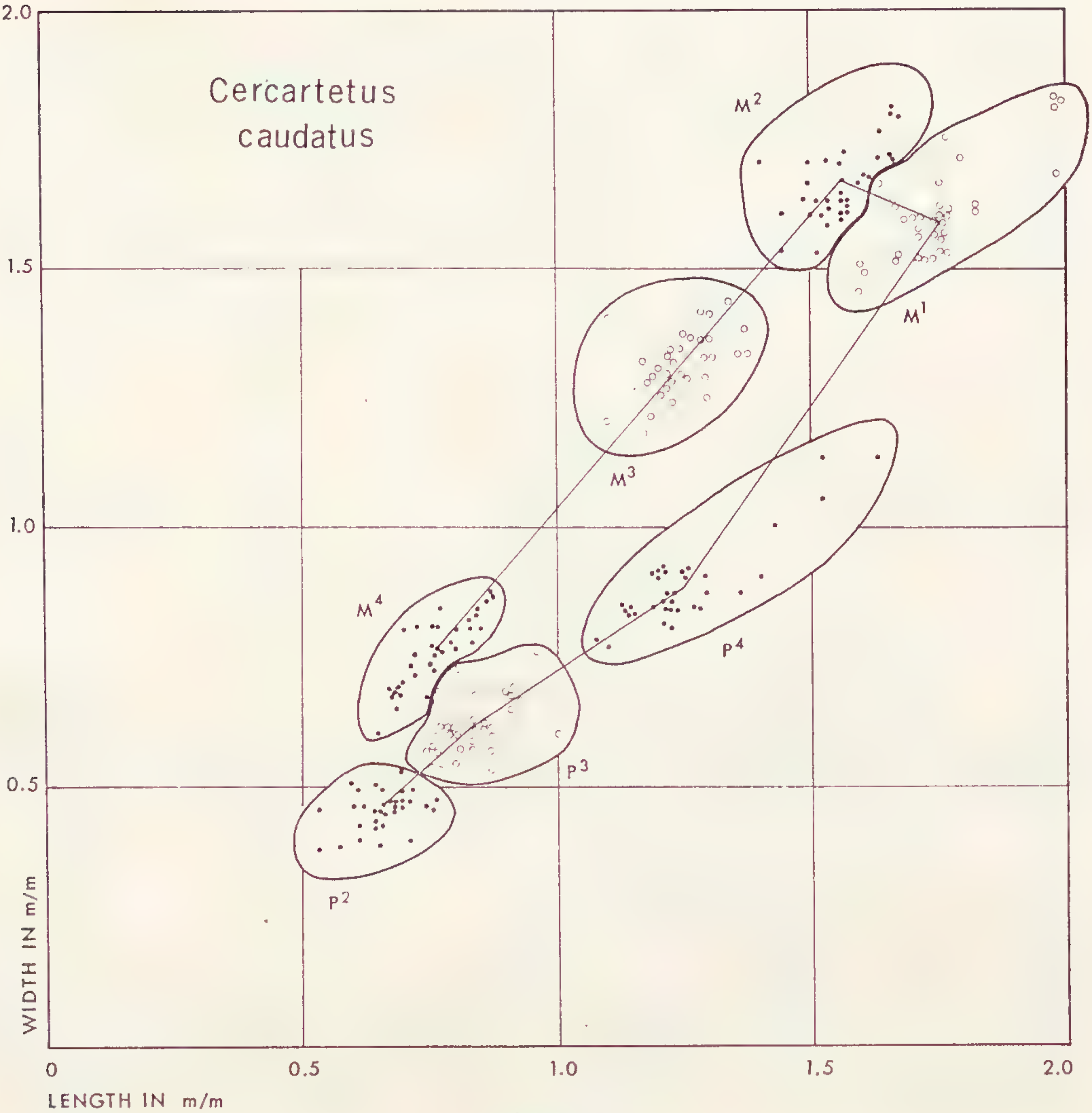


Figure 6

In *C. caudatus* the anterior two premolars are small, single-rooted but elongate. P4 is elongate, but is much shorter and narrower than any of the first three molars and has a large single cusp that shows an incipient clefting of its tip. M1 and M2 are large with nearly equal length and width measurements, M1 being slightly elongate. M3 is proportioned quite like M2 but is somewhat smaller and M4 is very reduced.

Figure 7 summarizes the upper cheek tooth proportions for each of these species and presents a vignette of the characteristic P4s. The latter shows the wide range of differences in the nature of that tooth from single cusped in *C. concinnus* and *C. caudatus* to definitely double-cusped in *C. lepidus* and *C. nanus*. Unworn specimens of *C. caudatus* show a tendency toward a clefting of the stout cusp, but all traces of this incipient division are readily erased by wear.

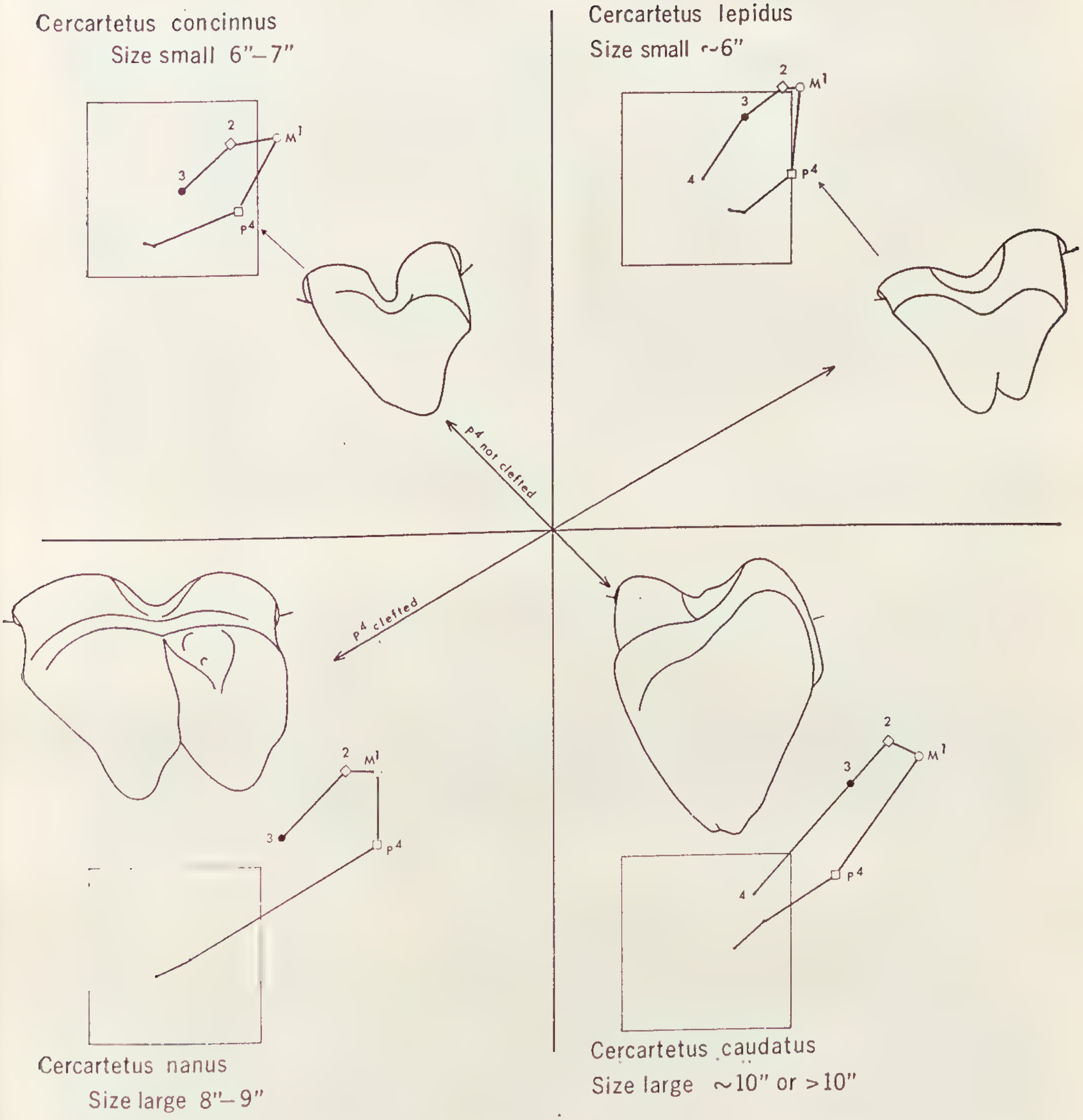


Figure 7. Comparisons of the patterns of the serially connected means of the bivariant tooth plots from Figs 3–6, along with a vignette of the $\mathrm{P}\frac{4}{-}$ of each species. Note that body size does not correlate with either clefting of $\mathrm{P}\frac{4}{-}$, or presence of $\mathrm{M}\frac{4}{4}$. Nor do these features correlate with one another, or with the Iredale & Troughton generic assignments to *Cercartetus* (left pair) and *Eudromicia* (right pair).

Note in figure 7 that size does not correlate with either premolar form or with presence or absence of the $M^{\underline{4}}$, the chief dental feature correlated with the Iredale and Troughton genera, *Cercartetus* and *Eudromicia.*

It would appear to us that these four species, *C. nanus*, *C. lepidus*, *C. concinnus* and *C. caudatus* are all distinctly different based on dental characters. The actual taxonomic history of these animals has been quite peripatetic and confusing. Desmarest (1817) described the species *Phalangista nana* which stood until Gray (1841) erected a separate genus *Dromicia* for this species. This was the common generic name in use for some years until it was discovered that Gloger (1841) had priority over Gray by several months with his genus *Cercartetus.* In 1845, Gould described the species *D. concinna* and in 1877, Milne-Edwards recognized the species *D. caudata.* Thomas (1888) in re-examining material of so-called "young" *D. nana* erected the separate species *D. lepida* based on the distinctive premolar differences. Mjöberg (1916) erected a new genus *Eudromicia*, to accommodate his new species *E. macrura* from New Guinea and placed in this genus *E. lepida* and *E. caudata.* Matschie (1916) preferred to delineate these forms still more and on the basis of pelage, ear shape, tail shape, molar number and size placed *D. lepida* in a separate subgenus *Dromiciola*, and *D. concinna* in the new subgenus, *Dromiciella.* Iredale and Troughton (1934) pointed out the priority of Gloger's *Cercartetus* and recognized only two genera: *Cercartetus* with *C. nanus* and *C. concinnus*, and *Eudromicia* with *E. caudata*, *E. macrura*, and *E. lepidus.* Finally, Wakefield (1963) synonymized *E. macrura* with *E. caudata* and somewhat arbitrarily minimized the cranial, dental and biological characters employed by previous authors and recognized only one genus, *Cercartetus.*

CONCLUSIONS

We feel that, at least dentally, these animals are not closely similar at all, and consequently they probably should not be placed within the same genus. But we also recognize the fact that our conclusions are based almost exclusively on dental anatomy, and that such one system based taxonomies are risky, and in this case unnecessary. Furthermore there is still uncertainty as to the level of confidence that one can place on inferences drawn from the sort of bivariate dental plots that we have used. As yet too few such graphic attempts have been made to provide an adequate basis for sound comparative judgements, although these that have appeared to date do seem to characterize both genera and species remarkably well.

Turnbull and Lundelius (1970) when seeking a meaningful comparative way to express graphically sets of observed dental proportions developed this technique. They showed (in their graphs F through I) that in the macropodids sampled, the species patterns were much alike within a genus and that allied genera differed in varying degrees—much as the species of *Cercartetus* differ from one another. In their graph E, in which various species groups of pseudocheirines were compared, the size range varied considerably, but the kinds of patterns observed conformed to established subgeneric and generic groupings. Here taxonomic interpretation is somewhat ambiguous: it suggests perhaps, that the genus *Pseudocheirus* (sensu lato) should be split (as Thomas, Troughton and Marlow have indeed done). The situation in *Cercartetus* is quite comparable as far as the dental graphs go, and it shows discrete, gross differences as to the form of the $P^{\underline{4}}$s, and the presence or absence of the $M^{\underline{4}}$s. Additionally, ongoing work by Lundelius and Turnbull (in press and MS), in which dentitions of the small phascogales are similarly treated, shows the genera *Planigale*, *Antechinus*, *Sminthopsis*, *Antechinomys* to have patterns far more alike than do those of the species of *Cercartetus*. In fact the graphic patterns for some of these genera are so alike that they do not always provide an easy means of distinguishing between them. Also the few such plots that one of us (WDT) has made for some of the other phalangerid genera appear to be of two sorts. At one extreme are *Acrobates*, *Distochoerus* and *Dactylopsila* where the differences are similar to those between the species of *Cercartetus*. At the other extreme *Petaurus* and *Gymnobelideus* are scarcely distinguishable. Therefore, on these comparative grounds, *Cercartetus* as presently constituted appears to encompass the sort of diversity of bivariant dental patterns within its four species that is usually found between several genera. Wakefield pointed out that variations in the tympanic bulla and squamosal inflation are also not consistent among the species. From what we have seen we would tend to agree, and this adds support to our contention that more than one genus is represented.

We feel that a more extensive and detailed examination of the biology of the four species of *Cercartetus* is in order and should precede any proposed taxonomic changes. Such a study would test the conclusions drawn from the dental evidence presented here. The dental differences are great enough to suggest strongly the recognition of four monotypic genera with the following species:

Cercartetus nanus (Desmarest) 1818.
Eudromicia caudata (Milne-Edwards) 1877.
Dromiciola lepida (Thomas) 1888.
Dromiciella concinna (Gould) 1845.

Pending the extensive restudy indicated above, we very reluctantly adhere to the arrangement of Wakefield. A partial synonymy of the genus *Cercartetus* and its included species following the Wakefield arrangement, listing the major systematic and nomenclatural changes for the pygmy possums, is given in Appendix C.

Other conclusions are that the Broom Cave specimens of *Cercartetus* differ in only minor ways from the Recent representatives of their species; the specific identities are thus confirmed. The rare *C. lepidus* of the fauna is now known from a small suite of materials. *C. nanus* turns out to be the most abundant marsupial in the fauna, approaching the murid taxa* in numbers of individuals within the sample.

SUMMARY

The largest sample to date of members of the genus *Cercartetus* from the Broom Cave fauna, Late Pleistocene, New South Wales, Australia, has been studied and discussed. Interspecific differences among *all* living species of *Cercartetus* are examined as well as morphologic variations within the Broom Cave material. Very strong evidence that the four living species of *Cercartetus* belong in separate monotypic genera is presented.

---

* Referred to by us (Schram & Turnbull, 1970) following earlier authors as *Pseudomys oralis* and *Gyomys glaucus* but Wakefield (pers. comm.) believes the former also includes *P. higginsi* and that the latter is a mixed sample of mostly *P. fumeus* and some *P. novaehollandiae*.

ACKNOWLEDGMENTS

We are grateful for discussions of pygmy possums which one or the other of us has had with John Calaby, Ernest Lundelius and Hobart VanDeusen. Michael Goodrich of Eastern Illinois University was consulted on a matter of systematics. The graphs and figures are the work of Tibor Perenyi of Field Museum, and photographs in Pls. 26, 27, 30 and 31 were made by Sam Silverstein, Field Museum volunteer. The Scanning Electron Microscope pictures in Pl. 25 were made in the Electron Optics Laboratory of the American Dental Association Research Institute by George Najarian on a Cambridge Stereoscan (John Lenke, in charge). Use of this S.E.M. facility was arranged by Harvey Lyon, Research Director, A.D.A. The several versions of the manuscript were typed by Winifred Reinders, Jeanette Forster and Mary Ann Rentfrow. We acknowledge the loan of comparative materials by the following persons and institutions: Hobart VanDeusen, American Museum of Natural History; Robert Green, Queen Victoria Museum, Launceston; Ernest Lundelius, Jr, University of Texas at Austin; and James Warren and A. K. Lee of Monash University. We thank each of you for your assistance.

BIBLIOGRAPHY

Desmarest, 1818. Nouveau Dictionaire d'Histoire Naturelle, Pas-Pho, Vol. 25: 477 Paris.

Gloger, 1841. Gemeinnutziges Hand-und Hilfsbuch der Naturgeschichte: 85.

Gould, J., 1845. On a small mammal (*Dromicia concinna*) from Western Australia. *Proc. zool. Soc., London.* 13: 2.

Gray, J. E., 1841. Contributions towards the geographical distribution of the Mammalia of Australia with notes on some recently discovered species; in G. Grey, Journals of two expeditions of discovery in northwest and western Australia. T. & W. Boone, London. Pp. 397–414.

Iredale, T. & Troughton, E. Le G., 1934. A checklist of the mammals recorded from Australia. *Mem. Aust. Mus.* 6: 1–122.

Marlow, B., 1962. Marsupials of Australia. Jacaranda Press, Brisbane, 1–141.

Matchie, P., 1916. Die Verbreitung der Beuteltiere auf Neuguinea. *Mitt. zool. Mus. Berl.* 8: 257–309.

Milne-Edwards, A., 1877. Note sur quelques Mammiferes nouveaux provenant de la Nouvelle-Guinée. *C.r. Acad. Sci., Paris.* 85: 1079–1081.

Mjöberg, E., 1916. On a new genus and species of marsupials. *K. svenska Vetensk.-Acad. Handl.* 52: 13–20.

Ride, W. D. L., 1960. The Fossil Mammalian Fauna of the *Burramys parvus* breccia from the Wombeyan Caves, New South Wales. *J. Roy. Soc. W. Aust.* 43: 74–80.

Schram, F. R., Turnbull, W. D., 1970. Structural composition and dental variations in the murids of the Broom Cave Fauna, Late Pleistocene, Wombeyan Caves area, N.S.W., Australia. *Rec. Aust. Mus.* 28: 1–24.

Thomas, O., 1888. Catalog of the Marsupialia and the Monotremata in the Collection of the British Museum (Natural History). London. Pp. i–xiii, 1–401, pls I–XXVIII.

Troughton, E. Le G., 1957. Furred Animals of Australia. Angus & Robertson, Sydney. Pp. i–xxxii, 1–376, pls 1–25.

Turnbull, W. D. and E. L. Lundelius, Jr, 1970. The Hamilton Fauna. A Late Pliocene Mammalian Fauna from the Grange Burn, Victoria, Australia. *Fieldiana Geol.* 19: 1–163, 1 fig., pls I–XXXI.

Wakefield, N. A., 1963. The Australian Pygmy Possums. *Vict. Nat.* 80: 99–116.

APPENDIX A

Materials listing of Broom Cave CERCARTETUS

Cercartetus nanus

Fragments from a palate, with L. M$^{\underline{1}}$, R. P$^{\underline{4}}$ and broken R. M$^{\underline{1}}$, PM7425; wear stage B.

L. Edentulous maxillary F52745.

L. Maxillae, wear stage—
- A: PM6162 with P$^{\underline{3}}$–M$^{\underline{2}}$, PM7431 with M$^{\underline{2}}$.
- B: PM7426 with P$^{\underline{4}}$, PM7446 with P$^{\underline{4}}$, PM17197 with P$^{\underline{4}}$–M$^{\underline{2}}$, F52671 with P$^{\underline{4}}$ and part of M$^{\underline{2}}$, F52723 with P$^{\underline{4}}$.
- C: F52670 with M$^{\underline{2}}$.

L. P$^{\underline{4}}$ wear stage—
- A: PM17224, F52717.
- B: PM7445, PM17219, PM17223, F52721.
- C: PM7444, PM17222, F52710, F52718, F52719.
- D: PM17221.

L. M$^{\underline{1}}$ wear stage—
- A: PM7428, F52707.
- B: PM17209, PM17211, PM17212, PM17213, PM17214, F52700, F52702, F52703, F52705, F52706.
- C: PM17207, PM17208, F52695, F52697, F52699.
- D: F52696.

L. M$^{\underline{2}}$, wear stage—
- B: PM7427, PM17204, PM17206, F52683, F52684, F52686, F52701.
- C: PM7580, PM7581, F52682.
- D: PM7429, PM7430.

L. M$^{\underline{3}}$, wear stage—
- B: PM7433, F52677.
- C: PM7583, PM7629, PM17199, PM17201, F52673, F52675, F52676.

R. Premaxillary with I$^{\underline{1}}$ and I$^{\underline{3}}$, PM7424.

R. Edentulous maxillary, F52724.

R. Maxillae, wear stage—
- B: PM17195 with P$^{\underline{4}}$–M$^{\underline{1}}$, PM17196 with P$^{\underline{4}}$–M$^{\underline{1}}$, F52720 with P$^{\underline{4}}$.
- C: PM7618 with P$^{\underline{3}}$–M$^{\underline{3}}$, F52669 with M$^{\underline{1}}$ (broken) –M$^{\underline{2}}$.
- D: F52668 with P$^{\underline{4}}$, M$^{\underline{2}}$ and M$^{\underline{3}}$.

R. P$^{\underline{4}}$, wear stage—
- B: PM7673, PM17217, PM17218, PM17220, F52713, F52714, F52715, F52716, F52722.
- C: PM7443, PM17215, PM17216, F52711, F52712.
- D: F52709.

R. M$^{\underline{1}}$, wear stage—
- A: PM7442, F52693, F52694.
- B: PM7438, PM7441, PM17210, PM17225, F52687, F52688, F52690, F52691, F52692, F52704, F52708.
- C: PM7437, F52689.

R. M$^{\underline{2}}$, wear stage—
- A: F52728.
- B: PM7439, PM7440, PM17202, PM17205, F52679, F52680, F52681, F52685.
- C: PM17203, F52678.

R. M$^{\underline{3}}$, wear stage—
- B: PM7584, PM17200, F52674.
- C: PM17198, F52672.
- D: PM7672.

L. Edentulous mandible PM17226.

L. Mandibles, wear stage—

A: PM6161 with $P_{\overline{3}}$–$M_{\overline{3}}$, F52620 with $P_{\overline{4}}$–$M_{\overline{1}}$.
B: PM7405 with $P_{\overline{4}}$–$M_{\overline{2}}$, PM16981 with $I_{\overline{1}}$, $P_{\overline{2}}$–$P_{\overline{4}}$, F52617 with $M_{\overline{1}}$–$M_{\overline{3}}$, F52618 with $P_{\overline{4}}$–$M_{\overline{2}}$.
C: PM7404 with $I_{\overline{1}}$, $P_{\overline{2}}$–$M_{\overline{1}}$, F52616 with $M_{\overline{1}}$–$M_{\overline{3}}$.
D: PM16980 with $P_{\overline{4}}$–$M_{\overline{3}}$.

L. $P_{\overline{4}}$, wear stage—

B: PM7420, PM7582, PM17191, F52663, F52667.
C: F52666.

L. $M_{\overline{1}}$, wear stage—

A: PM7423, F52661.
B: PM7422, PM17188, F52659, F52660.
C: PM7421, F52657, F52658.

L. $M_{\overline{2}}$, wear stage—

B: PM7417, PM7418, PM17182, F52636, F52644, F52645, F52646, F52652.
C: PM7416, PM7419, PM17000, PM17181, F52639, F52640, F52641, F52643.
D: PM16998, PM16999, F52637.

L. $M_{\overline{3}}$, wear stage—

B: PM7670, PM16989, PM16990, F52628, F52630.
C: PM16987, PM16988, F52626, F52627.

R. Edentulous mandibles PM7390, PM7403, PM16979A, PM26371, F52725, F52727.

R. Mandibles, wear stage—

A: F52615 with $P_{\overline{4}}$–$M_{\overline{3}}$, F52619 with $I_{\overline{1}}$ and $P_{\overline{4}}$.
C: PM16978 with $P_{\overline{4}}$–$M_{\overline{3}}$.

R. $P_{\overline{4}}$, wear stage—

A: PM17193.
B: PM17192, F52664.
C: PM17189.
D: F52662.

R. $M_{\overline{1}}$, wear stage—

B: PM7413, F52653, F52654.
C: PM7411, PM7414, PM17183, PM17187, F52649, F52651.
D: PM7412, F52647.

R. $M_{\overline{2}}$, wear stage—

A: PM7410.
B: PM16984, PM16996, PM16997.
C: PM7409, PM16991, PM16994, F52631, F52632, F52633, F52634, F52635.
D: PM7407.

R. $M_{\overline{3}}$, wear stage—

A: F52629.
B: PM7402, PM7406, PM16984, F52623, F52624.
C: PM16982, PM16983, F52621, F52622.

Cercartetus lepidus

R. $P^{\underline{4}}$

PM7578, F52771, F52772, F52773.

L. $P^{\underline{4}}$

PM7620, PM17246.

- L. M^{1}, wear stage—
  - A: PM7400.
  - B: F52774.
  - C: PM7401, F52775.
- R. M^{2}, wear stage—
  - C: F52769.
- L. M^{2}, wear stage—
  - B: F52776, F52777.
  - C: PM17247, PM17248.
- R. M^{3}, wear stage—
  - B: F52770.
- L. M^{3}, wear stage—
  - C: PM17245.
- Edentulous R. maxillae
  - PM17244, F52768.
- L. I_{1}
  - F52767.
- R. P_{4}
  - PM7394, F52782.
- L. P_{4}
  - PM7619, F52783.
- L. M_{1}, wear stage—
  - B: PM17249.
    F52784 (fragment).
- L. M_{2}, wear stage—
  - A: PM7398.
  - C: PM7399, PM17250.
- L. M_{3}, wear stage—
  - C: PM7393.
- L. Mandible with P_{4}, PM6163.
- L. Mandible with I_{1}, F52780.
- L. Edentulous mandibles
  - PM7389, F52781.
- R. Edentulous mandibles
  - PM7391, PM7392, F52778, F52779.

C. lepidus?

- PM7395, PM7396, F52765, F52766.

APPENDIX B

Age group assignments of the teeth of the Broom Cave *Cercartetus nanus* and *C. lepidus*, using the wear stages A through D. These are as follows:

(A) Cusps very sharp and clear, little or no wear.
(B) Wear of enamel beginning, cusp slightly round, wear facets appearing.
(C) Wear of enamel well advanced, cusps clearly worn down.
(D) Tips of cusps almost gone, with dentine exposed and beginning to wear.

First column under each age group gives numbers of individual teeth. Second columns give the maximum numbers of specimens of that molar quadrant that are represented by the individual teeth of the first columns after all known correlations have been accounted for.

Cercartetus nanus

	A		B		C		D		Totals	
	Teeth	Spec.	Teeth	Spec.	Teeth	Spec.	Teeth	Spec.	Teeth	Spec.
L. $P^{\underline{4}}$	3	6	9	29 63	5	21	1	4	18	60 114
L. $M^{\underline{1}}$	3		12		5		1		21	
L. $M^{\underline{2}}$	2		9		4		2		17	
L. $M^{\underline{3}}$	0		2		7		0		9	
R. $P^{\underline{4}}$	0	4	13	35	6	13	2	3	21	55
R. $M^{\underline{1}}$	3		14		4		0		21	
R. $M^{\underline{2}}$	1		8		4		1		14	
R. $M^{\underline{3}}$	0		3		3		2		8	
L. $P^{\underline{4}}$	2	4	8	26 39	2	18	1	4	13	52 94
L. $M^{\underline{1}}$	4		7		5		1		17	
L. $M^{\underline{2}}$	1		11		9		4		*25	
L. $M^{\underline{3}}$	1		6		5		1		13	
R. $P^{\underline{4}}$	3	5	2	13	2	20	1	4	8	42
R. $M^{\underline{1}}$	1		3		7		2		13	
R. $M^{\underline{2}}$	2		3		9		1		15	
R. $M^{\underline{3}}$	2		5		5		0		12	
Total number of teeth	28	..	115	..	82	..	20	..	245	..
Total number of specimens ..	..	19	..	102	..	72	..	15	..	208****
Most frequently represented tooth	4	..	14	..	9	..	4	..	**31	..
No. of specimens in largest suite ..	..	6	..	35	..	21	..	4	..	66***

* Traditional assessment of minimum number of individuals.

**** Absolute maximum number of specimens and individuals (based on all teeth, correlated and uncorrelated).

** Age-spread assessment of minimum number of individuals.

*** Minimal estimate of max. number of individuals.

Cercartetus lepidus

	A		B		C		D		Totals	
	Teeth	Spec.	Teeth	Spec.	Teeth	Spec.	Teeth	Spec.	Teeth	Spec.
L. $P^{\underline{4}}$	0	1	2	5	0	5	0	0	2	11
L. $M^{\underline{1}}$	1		1		2		0		*4	
L. $M^{\underline{2}}$	0		2		2		0		4	
L. $M^{\underline{3}}$	0		0		1		0		1	
L. $M^{\underline{4}}$	0		0		0		0		0	
R. $P^{\underline{4}}$	0	0	2	3	1	1	0	0	3	4
R. $M^{\underline{1}}$	0		0		0		0		0	
R. $M^{\underline{2}}$	0		1		0		0		1	
R. $M^{\underline{3}}$	0		0		0		0		0	
R. $M^{\underline{4}}$	0		0		0		0		0	
L. $P^{\underline{4}}$	0	1	3	4	0	4	0	0	3	9
L. $M^{\underline{1}}$	0		1		1		0		2	
L. $M^{\underline{2}}$	1		0		2		0		3	
L. $M^{\underline{3}}$	0		0		1		0		1	
L. $M^{\underline{4}}$	0		0		0		0		0	
R. $P^{\underline{4}}$	0	0	2	2	0	0	0	0	2	2
R. $M^{\underline{1}}$	0		0		0		0		0	
R. $M^{\underline{2}}$	0		0		0		0		0	
R. $M^{\underline{3}}$	0		0		0		0		0	
R. $M^{\underline{4}}$	0		0		0		0		0	
Total number of teeth	1	..	14	..	10	..	0	..	26	..
Total number of specimens	..	2	..	14	..	10	..	0	..	****26
Most frequently represented tooth	1	..	3	..	2	..	0	..	**6	..
No. of specimens in largest suite	..	1	..	5	..	5	..	0	..	***11

APPENDIX C

Partial synonymy of the genus *Cercartetus* and its species with the major systematic and nomenclatural sources.

Cercartetus Gloger 1841

1841. *Cercartetus* Gloger, Handb. u. Hilfsb. Nat., p. 85.
1841. *Dromicia* Gray, in Grey, Journ. of Two Expeditions of Discovery in Northwest and Western Australia during the years 1837, '38, and '39. T. and W. Boone. London.
1916. *Eudromicia* Mjöberg, Kungl. Sveska Vetenskapsakademiens Handlingar. **52:** 2, pp. 13–20. January.
1934. *Cercartetus* and *Eudromicia* Iredale and Troughton. Records of the Australian Museum **6:** 1, pp. 22–23.
1963. *Cercartetus* Wakefield. Victorian Naturalist **80:** August, pp. 99–116.

C. nanus (Desmarest) 1818

1818. *Phalangista nana* Desmarest. Nouveau Dictionairie d'Histoire Naturelle, Pas-Pho. Tome XXV, p. 477.
1841. *Cercartetus nanus* Gloger.
1841. *Dromicia nana* Gray (in Grey).
1916. *D. nana,* Mjöberg.
1916. *D. nana,* Matchie.
1934. *Cercartetus nanus,* Iredale and Troughton.
1963. *C. nanus,* Wakefield.

C. caudatus (Milne-Edwards) 1877

1877. *Dromicia caudata* Milne-Edwards. Paris Academie des Science Comptes Rendus. Tome **85:** pp. 1079–1080.
1916. *Eudromicia caudata,* Mjöberg.
1916. *E. macrura* Mjöberg.
1916. *E. caudata,* Matchie.
1916. *E. macrura,* Matchie.
1934. *E. macrura,* Iredale and Troughton.
1963. *Cercartetus caudatus caudatus,* Wakefield.
1963. *C. c. macrurus,* Wakefield.

C. lepidus (Thomas) 1888

1888. *Dromicia lepida.* Catalog of the Marsupials and Monotremes. Brit. Mus. London. pp. 142–143.
1916. *Eudromicia lepida,* Mjöberg.
1916. *E.* (*Dromiciola*) *lepida,* Matchie.
1934. *Eudromicia lepida,* Iredale, Troughton.
1963. *Cercartetus lepidus,* Wakefield.

C. concinnus (Gould) 1845

1845. *Dromicia concinnia* Gould. Proc. Zool. Soc. (London) 1845, p. 2.
1916. *D. concinna,* Mjöberg.
1916. *D.* (*Dromiciella*) *concinna,* Matchie.
1934. *Cercartetus concinnus,* Iredale and Troughton.
1963. *C. concinnus,* Wakefield.

TABLE 1. Statistical data for tooth measurements of *Cercartetus nanus* from Broom Cave

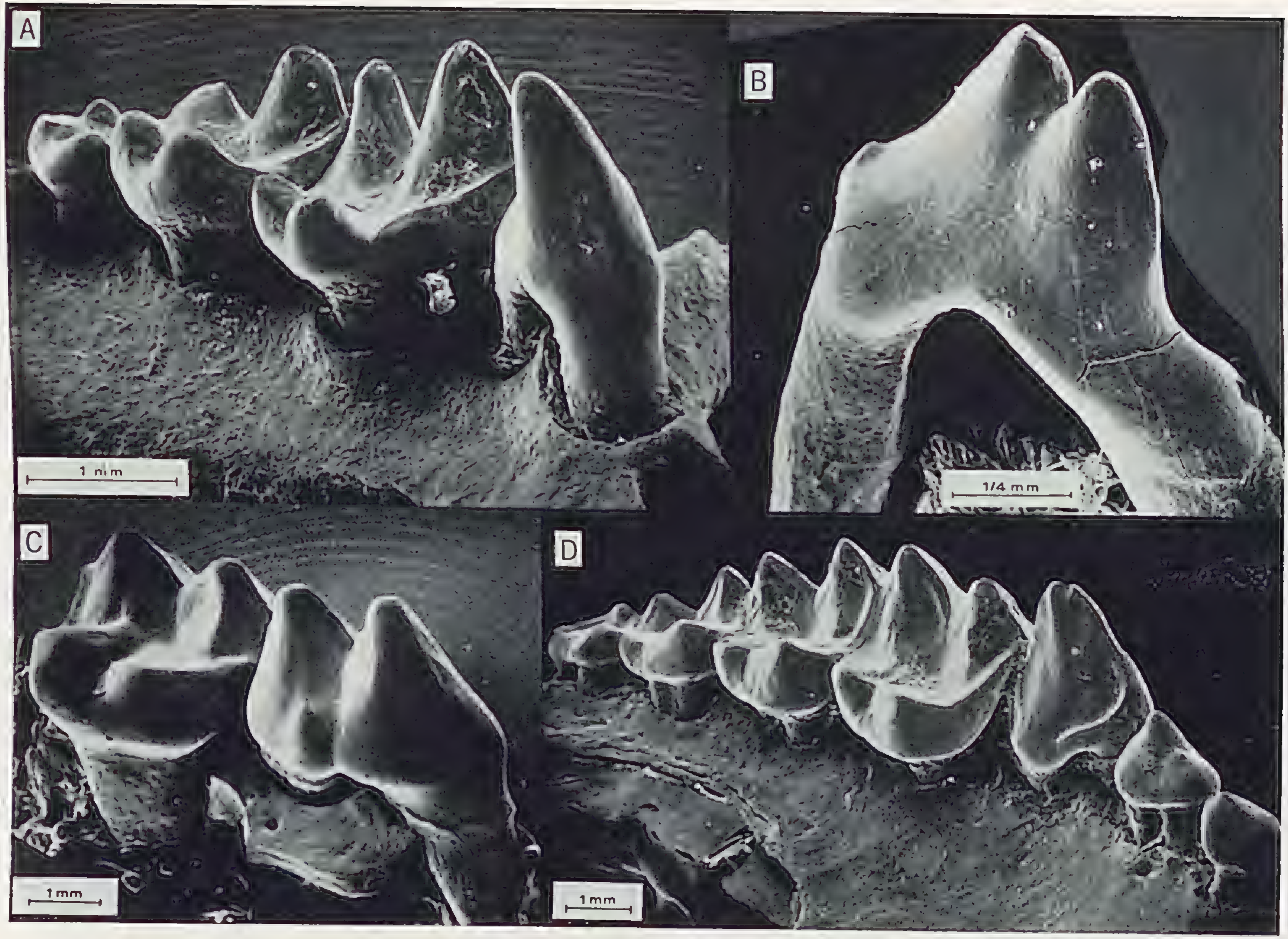
		N	$\bar{X}$	S	V	Observed range
L.	P^4	34	1.67 ± .01	.08	4.78	1.50–1.85
W.	P^4	35	1.14 ± .02	.12	10.24	.96–1.25
L.	M^1	42	1.68 ± .02	.10	6.13	1.40–1.85
W.	M^1	39	1.56 ± .01	.08	4.89	1.40–1.65
L.	M^2	28	1.49 ± .01	.07	4.72	1.34–1.65
W.	M^2	27	1.54 ± .02	.08	5.15	1.40–1.70
L.	M^3	17	1.09 ± .01	.04	3.71	1.00–1.15
W.	M^3	17	1.13 ± .02	.07	6.08	1.00–1.25
L.	P_4	20	1.32 ± .04	.16	12.21	1.15–1.85
W.	P_4	20	.89 ± .02	.11	12.50	.75–1.10
L.	M_1	29	1.57 ± .01	.08	5.01	1.40–1.70
W.	M_1	28	1.14 ± .02	.09	8.10	.95–1.35
L.	M_2	38	1.61 ± .01	.07	4.34	1.40–1.75
W.	M_2	38	1.21 ± .01	.08	7.03	1.00–1.40
L.	M_3	21	1.31 ± .02	.09	6.48	1.20–1.55
W.	M_3	23	1.02 ± .01	.06	6.23	.90–1.15

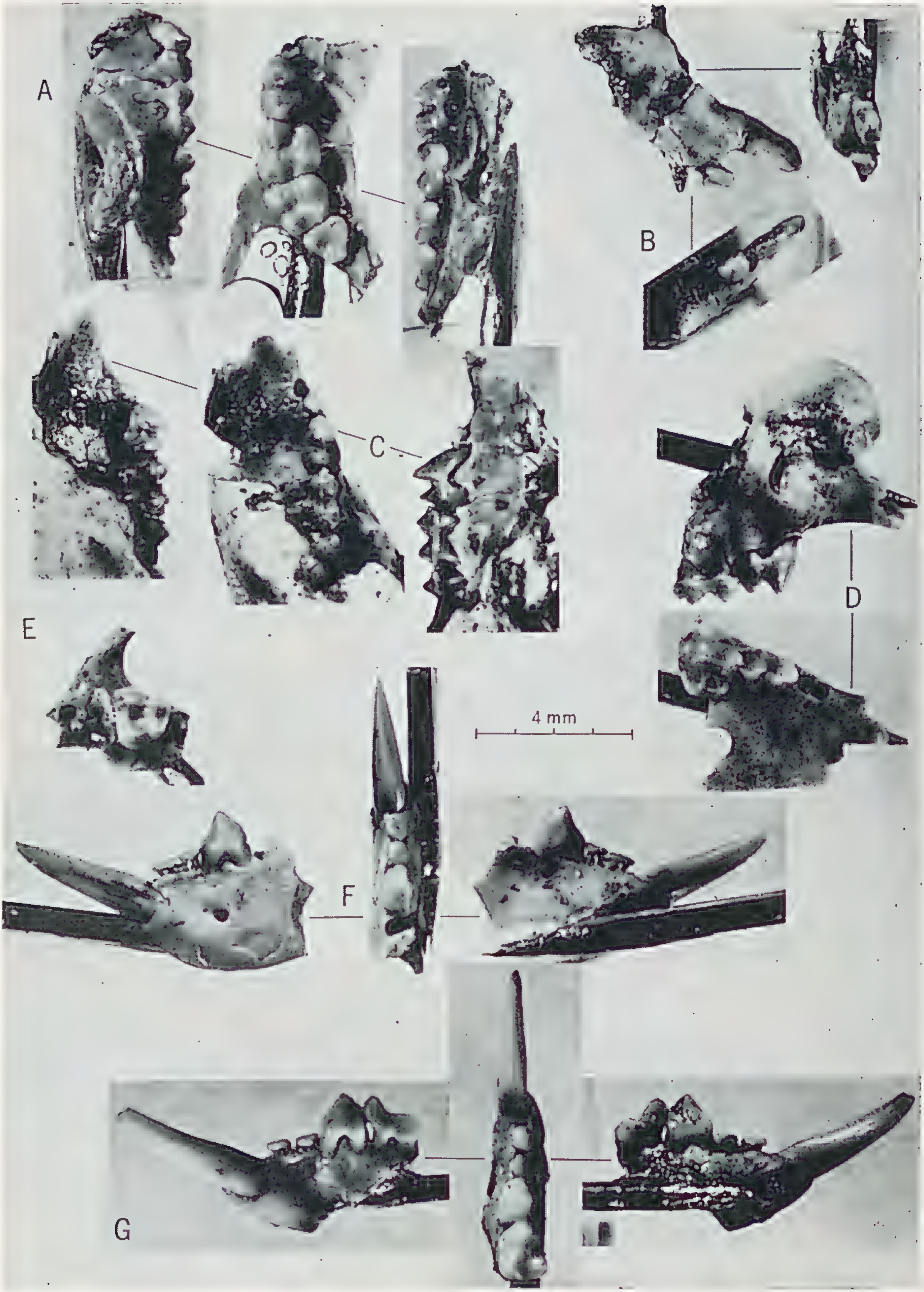
TABLE 2. Statistical data for tooth measurements of *Cercartetus lepidus* from Broom Cave

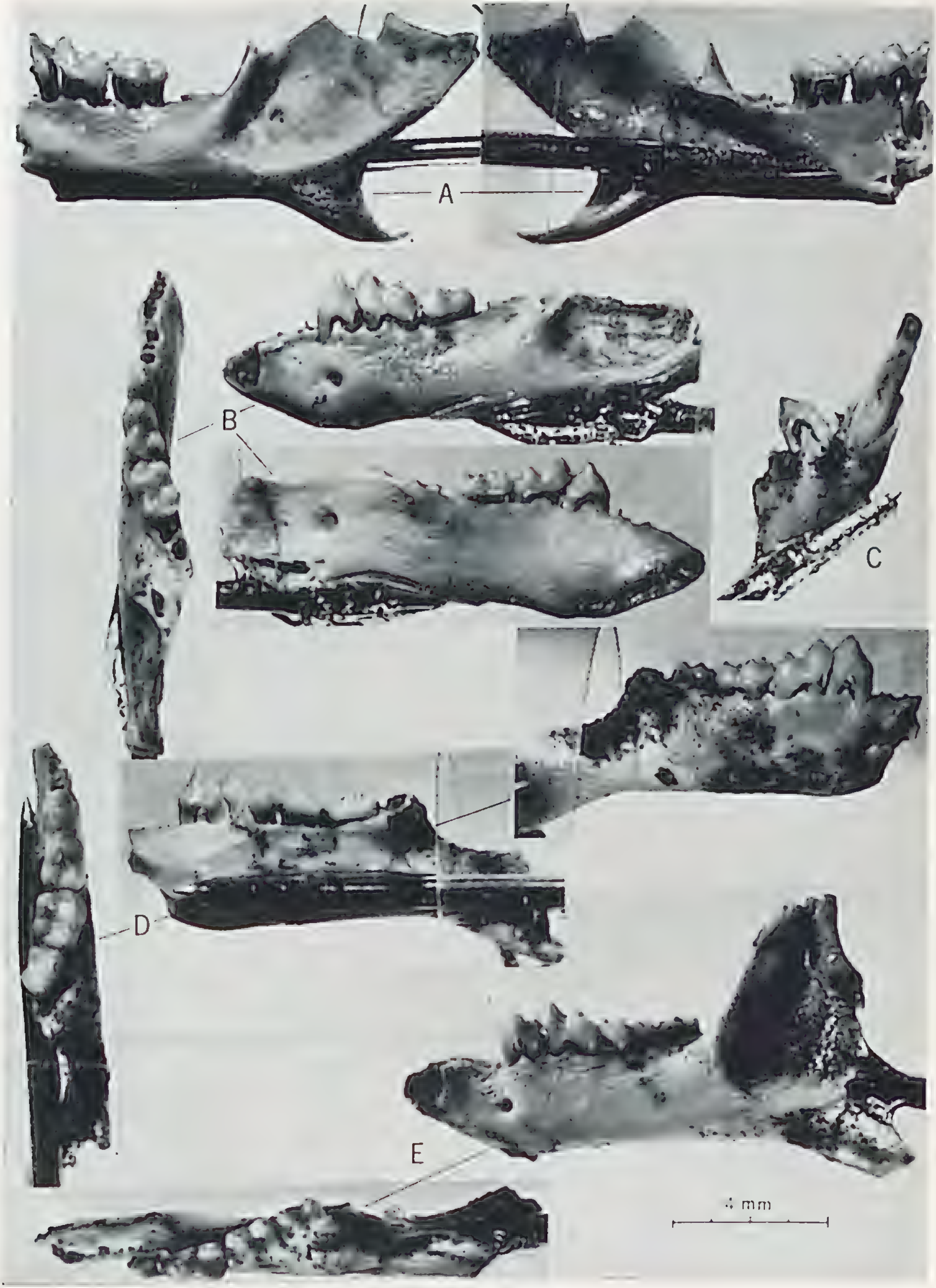
		N	$\overline{X}$	S	V	Observed range
L.	P^{4}	4	1.07 ± .03	.06	5.96	.99–1.14
W.	P^{4}	5	.55 ± .02	.05	9.69	.49– .61
L.	M^{1}	4	1.14 ± .05	.09	8.10	1.06–1.22
W.	M^{1}	4	1.10 ± .02	.05	4.49	1.05–1.14
L.	M^{2}	5	1.00 ± .02	.05	5.03	.95–1.05
W.	M^{2}	5	1.04 ± .02	.05	4.59	.99–1.10
L.	M^{3}	2	.78 ± .02	.03	3.63	.76– .80
W.	M^{3}	2	1.00 ± .05	.08	7.74	.95–1.06
L.	M^{4}	..	....	..	..	....
W.	M^{4}	..	....	..	..	....
L.	P_{4}	5	.88 ± .03	.06	7.05	.84– .99
W.	P_{4}	5	.47 ± .02	.04	8.66	.42– .53
L.	M_{1}	2	1.21 ± .15	.22	18.04	1.06–1.37
W.	M_{1}	1	.87	..	..	.87
L.	M_{2}	3	1.00 ± .03	.05	5.05	.95–1.05
W.	M_{2}	3	.71 ± .05	.08	11.18	.65– .80
L.	M_{3}	1	.95	..	..	.95
W.	M_{3}	1	.61	..	..	.61
L.	M_{4}	..	....	..	..	....
W.	M_{4}	..	....	..	..	....

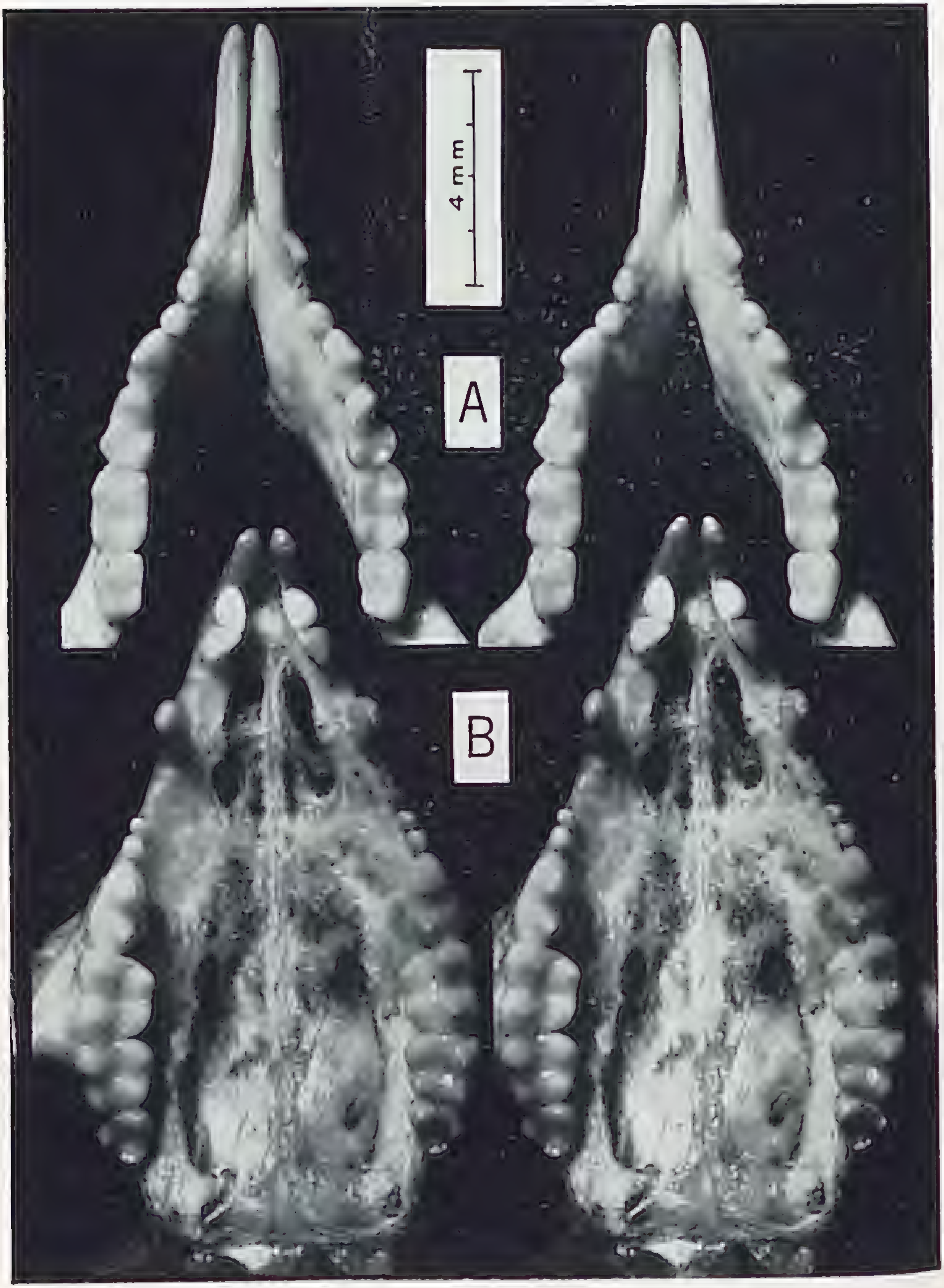
TABLE 3. Relative abundance of the pygmy possums of the Broom Cave Fauna. (For explanation of parameters used, see Schram and Turnbull 1970)

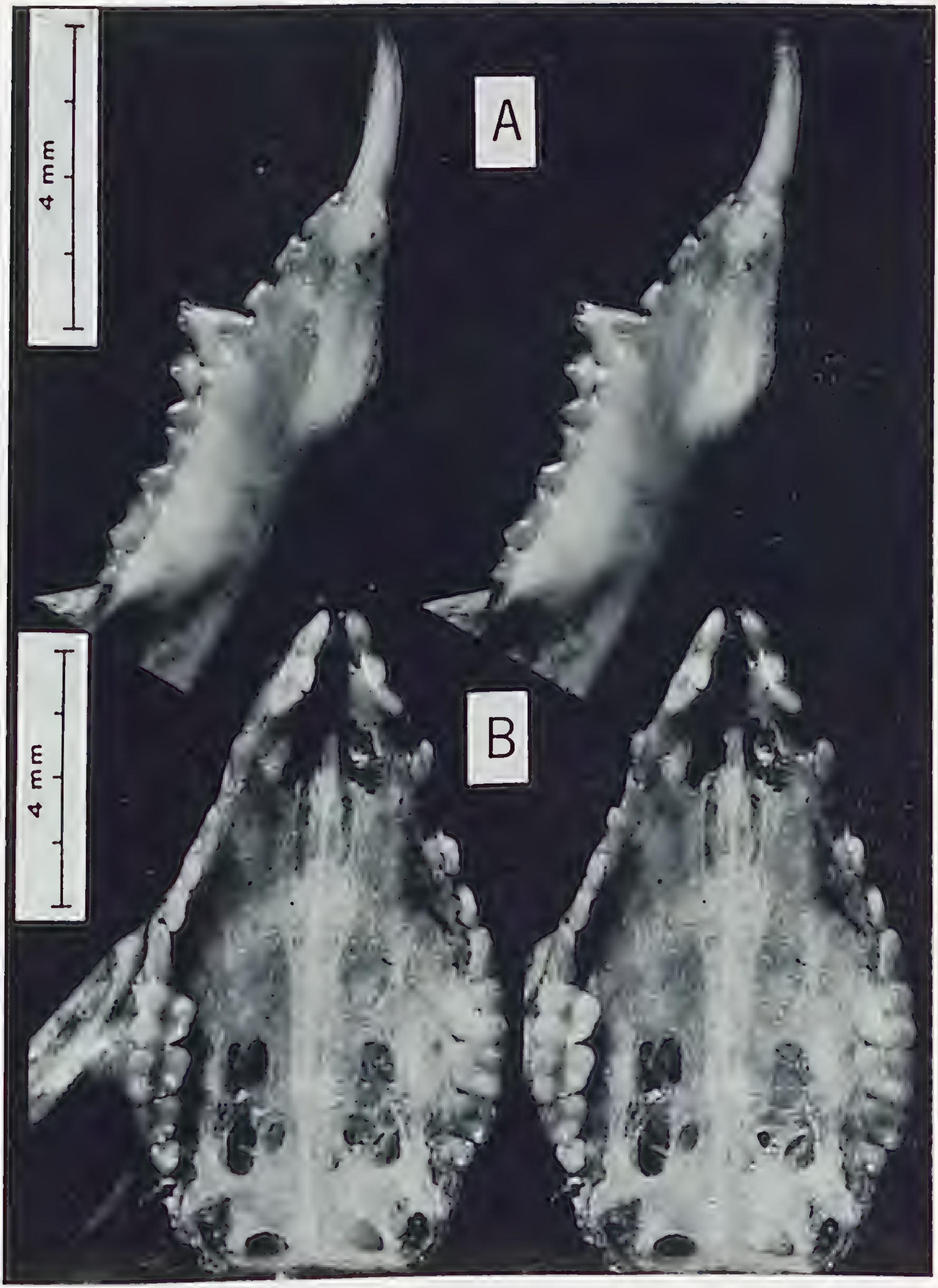
		Various estimates of numbers of individuals			
		Minimum number		Maximum number	
	No. of teeth	Traditional	Age-spread	Minimum est. of maximum	Absolute maximum
Cercartetus nanus ..	245	25	31	66	208
Cercartetus lepidus ..	26	4	6	11	26

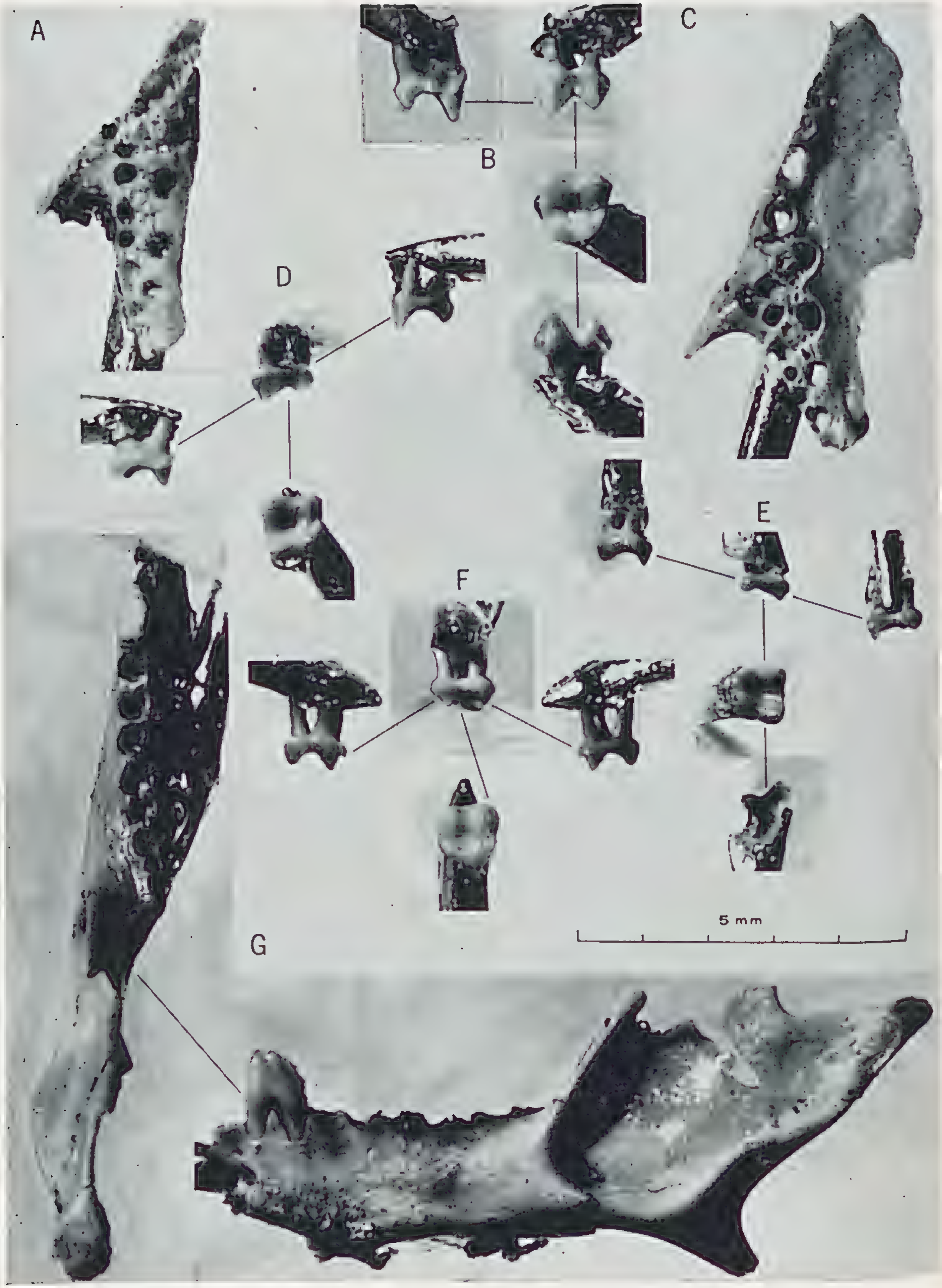

A
1 mm
B
1/4 mm
C
1mm
D
1mm

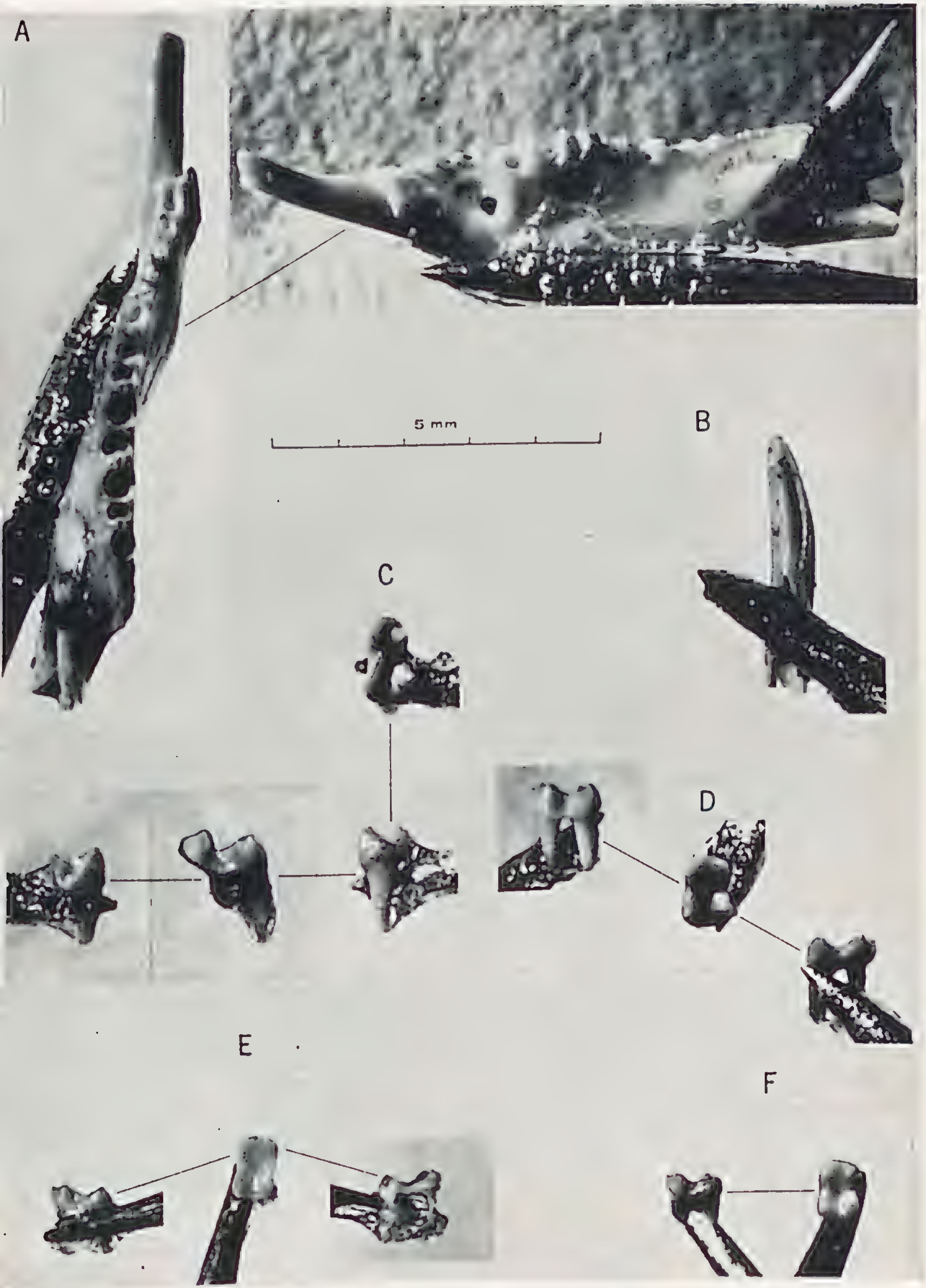

A
B
C
D
E
4 mm
F
G


A
B
C
D
E
4 mm


4 mm
A
B


4 mm
A
4 mm
B


A
B
C
D
E
F
G
5 mm


A
5 mm
B
C
D
E
F

EXPLANATION OF PLATES

Plate 25

(Scales indicate length of 1 mm in A, C, and D; ¼ mm in B)

Scanning electron microscope photographs showing a part of the upper dentition of each of the four species of *Cercartetus*. In each case the specimen is shown inverted from its normal orientation, and is viewed somewhat antero-medially. The great depth of field and high resolution capabilities of SEM make it an ideal tool for photography of dentitions of small mammals even at these low magnifications.

A. *Cercartetus concinnus*, PM19462, sub-Recent fossil, from Murraelellevan Cave, W.A., a right maxillary with $P^{\underline{4}}$–$M^{\underline{3}}$.

B. *C. lepidus*, PM17246, Late Pleistocene, from Broom Cave, Wombeyan Caves area, N.S.W., an isolated right $P^{\underline{4}}$.

C. *C. nanus*, PM17195, Late Pleistocene, Broom Cave, fragment of a right maxillary with $P^{\underline{4}}$–$M^{\underline{1}}$.

D. *C. caudatus*, AMNH109807, Recent, 2200m., 18 km North of Lake Habbema, Bele R., Netherlands New Guinea, a right maxillary with the complete cheek tooth series.

Plate 26

(Scale indicates length of 4 mm)

Photographs of a series of specimens (all partial dentitions) selected as representative of the Broom Cave remains of *Cercartetus nanus*. These specimens and those shown in Pls. 27, 30, and 31 were removed from the entombing travertine by dissolution of the matrix with 10 per cent acetic acid.

A. PM7618, a right maxillary with $P^{\underline{3}}$–$M^{\underline{3}}$ shown in labial, crown and lingual views.

B. PM7424, a right premaxillary with $I^{\underline{1}}$ and $I^{\underline{3}}$ shown in lateral, occlusal and anterior views.

C. PM6162, a left maxillary with $P^{\underline{3}}$–$M^{\underline{1}}$ and part of $M^{\underline{2}}$ shown in lingual, crown and labial views.

D. PM17196, fragment of a right maxillary with $P^{\underline{4}}$–$M^{\underline{1}}$ shown in labial and crown views.

E. F52670, fragment of a left maxillary with $M^{\underline{2}}$ in crown view.

F. PM16981, partial left mandible with $I_{\overline{1}}$ and all three premolars shown in labial, crown and lingual views.

G. PM7404, partial left mandible with $I_{\overline{1}}$, all premolars and $M_{\overline{1}}$ shown in labial, crown and lingual views.

Plate 27

(Scale indicates length of 4 mm)

Continuation of the series of photographs of the Broom Cave *Cercartetus nanus* specimens.

A. F52618, a left mandible with part of $P_{\overline{4}}$, with $M_{\overline{1}}$–$_{\overline{2}}$ and preserving most of the masseteric fossa and the condyle, and all of the angular process. Shown in labial and lingual views.

B. PM7405, a left mandible with $P_{\overline{4}}$–$M_{\overline{2}}$, and alveolae of all other teeth shown in crown, labial and lingual views.

C. F52619, partial right mandible with $I_{\overline{1}}$ (showing peculiar wear) and $P_{\overline{4}}$ seen in lateral view (slightly antero-ventro-lateral).

D. F52615, a right mandible with $P_{\overline{4}}$–$M_{\overline{3}}$ shown in crown, lingual and labial views.

E. PM16980, a left mandible with $P_{\overline{4}}$–$M_{\overline{3}}$ shown in labial and crown views.

Plate 28

(Scale indicates length of 4 mm)

Stereoscopic photo-pairs of the dentition of a Recent specimen of *Cercartetus nanus*, Q.V.M. 1963 : 1 : 14. The mandibles are shown in dorsal view and the palate and upper dentition is shown in ventral (crown) view.

Plate 29

(Scales indicate length of 4 mm., note that upper and lower dentitions are shown at slightly different scales)

Stereoscopic photo-pairs of the dentition of a Recent specimen of *Cercartetus lepidus*, Q.V.M. 1964 : 1 : 249. The left mandible is shown in lingual view; the palate and upper dentition in ventral (crown) view.

Plate 30

(Scale indicates length of 5 mm)

Photographs of series of Broom Cave specimens of *Cercartetus lepidus*.

A. and C., PM17224 and F53768 respectively. Edentulous right maxillaries shown in palatal view. Each preserves alveolae of the full cheek tooth series.

B. PM7400, a left $M^{\underline{1}}$ shown in anterior, labial, crown and lingual views.

D. and F., F52700 and F52869 respectively. Right $M^{\underline{2}}$s shown in labial, anterior, crown and posterior views.

E. F52770, a right $M^{\underline{3}}$, shown in posterior, labial, anterior, crown and lingual views.

G. PM6163, a left ramus with $P_{\overline{4}}$ shown in dorsal (crown) and lateral (labial) views.

Plate 31

(Scale indicates length of 5 mm)

Continuation of the series of specimens of *Cercartetus lepidus* from Broom Cave.

A. F52780, a left ramus with $I_{\overline{1}}$ and alveolae of the rest of the teeth shown in dorsal and lateral views.

B. F52767, a left $I_{\overline{1}}$ and alveolae of the rest of the teeth shown in dorsal and lateral views

C. PM17249, a left $M_{\overline{1}}$ shown in anterior, labial, posterior and crown views.

D. and E., PM17250 and PM7398 respectively. Left $M_{\overline{2}}$s shown in labial, crown and lingual views.

F. PM7393, a left $M_{\overline{3}}$ shown in crown and labial views.

INDEX

PAGE

A

aculeata, Galathea 280
Alathyria profuga 37
Aliaporcellana suluensis 285
Allogalathea elegans 275
Alpheopsis equalis 342
  trispinosus 337
  undicola 340
  yaldwyni 344
amabilis, Aretopsis 330
Anadara trapezia 121
Anchisquilla mcneilli 84
angasi, Ostrea 121
areteformis, Athanas 304
Aretopsis amabilis 330
armata, Stereonephthya 101
Athanas areteformis 304
  dimorphus 313
  dorsalis 324
  granti 316
  haswelli 316
  indicus 327
  ornithorhynchus 319
  sibogae 321
  djiboutensis 306
  japonicus 308
  locincertus 311
australia, Hyridella 37
australiensis, Galathea 277
  Kelleria 111
  Manningia 78
australis, Betaeus 347
  Pectiniseta 150
  Typton 254
Automate dolichognatha 299

B

balssi, Galathea 278
barnesi, Robertsonia 430
Bassianobdella fusca 133
bellissima, Stereonephthya 102
bengalensis, Onychocamptus 406
Betaeus australis 347
Bettongia 48

PAGE

C

caudatus, Cercartetus 450
celmisiae, Megascolex 242
Cercartetus caudatus 450
  concinnus 451
  lepidus 442
  nanus 438
chabrolii, Nepthea 94
Chlorinoides goldsboroughi 67
  occidentalis 70
  tenuirostris 76
Cletocamptus deitersi 414
coerulea, Heliopora 107
commercialis, Crassostrea 121
compressus, Racilius 350
concinnus, Cercartetus 451
costatocyanea, Stereonephthya 97
costatofulva, Stereoneyhthya 96
crassospiculatum, Lobophytum 90
Crassostrea commercialis 121
Cryptodrilus fastigatus 229
  tenuis 233
Cucumerunio novaehollandiae 37

D

deitersi, Cletocamptus 414
Dendronephthya (Morchellana) spinosa 104
dimorphus, Athanus 313
Diporochaeta pheretima 217
dispar, Pisidia 284
djiboutensis, Athanas 306
dolichognatha, Automate 299
doriae, Nelima 385
dorsalis, Athanus 324

E

ehrenbergi, Sarcophyton 91
elegans, Allogalathea 275
elegantissima, Munida 270
equalis, Alpheopsis 342

PAGE

F

- *fastigatus, Cryptodrilus* 229
- *frenchi, Vesiculodrilus* 225
- *fulvithorax, Pectiniseta* 154
- *fusca, Bassianobdella* 133
- *fuscus, Melomys* 24

G

- *Galathea aculeata* 280
  - *australiensis* 277
  - *balssi* 278
  - *magnifica* 280
- *glaucum, Sarcophyton* 92
- *glaucus, Gyomys* 14
- *goldsboroughi, Chlorinoides* 67
- *gordoni, Pisidia* 283
- *Graliophilus montiskosciuskoi* 219
  - *woodi* 221
- *granti, Athanas* 316
- *Gyomys glaucus* 14

H

- *haswelli, Athanas* 316
  - *Munida* 273
- *Heliopora coerulea* 107
- *Heterolaophonte quinquespinosa* 403
  - *sigmoides* 403
  - *wellsi* 394
- *Heterosquilla (Heterosquilloides) insueta* 81
- *(Heterosquilloides), Heterosquilla, insueta* 81
- *hirsuta, Trichomya* 121
- *Hyridella australia* 37

I

- *imparicystis, Oreoscolex* 239
- *indicus, Athanas* 327
- *insueta, Heterosquilla (Heterosquilloides)* 81

J

- *japonica, Munida* 271
- *japonicus, Athanas* 308

K

- *Kelleria australiensis* 111

L

- *lepidus, Cercartetus* 442
- *Lobophytum crassospiculatum* 90
  - *pauciflorum* 89
- *ocincertus, Athanas* 311
- *ongicaulis, Stereonephthya* 99

PAGE

M

- *Macropus major* 37
- *magnifica, Galathea* 280
- *major, Macropus* 37
- *Manningia australiensis* 78
- *Mastacomys wombeyensis* 7
- *mcneilli, Anchisquilla* 84
- *Megascolex celmisiae* 242
- *Melomys platyops fuscus* 24
- *microps, Munida* 271
- *monticola, Notuchus* 266
- *montiskosciuskoi, Graliophilus* 219
  - *notoscolex* 236
- *(Morchellana), Dendronephthya spinosa* 104
- *moseri, Sarcophyton* 90
- *Munida elegantissima* 270
  - *haswelli* 273
  - *japonica* 271
  - *microps* 271
  - *subrugosa* 274
- *musica, Tubipora* 88
- *Mytilus planulatus* 121

N

- *nanus, Cercartetus* 438
- *Nelima doriae* 385
- *Nephthea chabrolii* 94
- *Notoscolex montiskosciuskoi* 236
- *Notuchus monticola* 266
- *novaehollandiae, Cucumerunio* 37

O

- *obesulus, Polyonyx* 285
- *occidentalis, Chlorinoides* 70
- *occulta, Pectiniseta* 149
- *Onychocamptus bengalensis* 406
- *oralis, Pseudomys* 12
- *Oreoscolex imparicystis* 239
- *ornithorhynchus, Athanus* 319
- *Ostrea angasi* 121

P

- *Pachycheles sculptus* 282
- *pauciflorum, Lobophytum* 89
- *pectinata, Pectiniseta* 144
- *Pectiniseta australia* 150
  - *fulvithorax* 154
  - *occulta* 149
  - *pectinata* 144
  - *similis* 147
  - *societas* 154
  - *torresiana* 152

PAGE

pheretima, Diporochaeta 217
Phylladiorhynchus pusillus 282
Pisidia dispar 284
  gordoni 283
planulatus, Mytilus 121
platyops, Melomys 24
polydactyla, Sinularia 93
Polyonyx obesulus 285
profuga, Alathyria 37
propinqua, Robertsonia 422
Pseudocheirus 48
Pseudomys oralis 12
purpureus, Vesiculodrilus 227
pusillus, Phylladiorhynchus 282

Q

quinquespinosa, Heterolaophonte 403

R

Racilius compressus 350
Rattus sp. 15
Robertsonia barnesi 430
  propinqua 422

S

Salmoneus tricristatus 334
Sarcophyton ehrenbergi 91
  glaucum 92
  moseri 90
  trocheliophorum 92
sculptus, Pachycheles 282
sibogae, Athanas 321
sigmoides, Heterolaophonte 403
similis, Pectiniseta 147
Sinularia polydactyla 93
societas, Pectiniseta 154
spinosa, Dendronephthya
  (Morchellana) 104
Stereonephthya armata 101
  bellissima 102
  costatocyanea 97
  costatofulva 96
  longicaulis 99
  whiteleggi 95
subrugosa, Munida 274
suluensis, Aliaporcellana 285

PAGE

T

tenuirostris, Chlorinoides 76
tenuis, Cryptodrilus 233
torresiana Pectiniseta 152
trapezia, Anadara 121
Trichomya hirsuta 121
Trichosurus vulpecula 37
tricristatus, Salmoneus 334
trispinosus, Alpheopsis 337
trocheliophorum, Sarcophyton 92
Tubipora musica 88
Typton australis 254

U

undicola, Alpheopsis 340

V

Vesiculodrilus frenchi 225
  purpureus 227
vulpecula, Trichosurus 37

W

Wallabia 37
wellsi, Heterolaophonte 394
whiteleggi, Stereonephthya 95
wombeyensis, Mastacomys 7
woodi, Graliophilus 221

Y

yaldwyni, Alpheopsis 344

60108 10.73 V. C. N. BLIGHT, GOVERNMENT PRINTER

NATIONAL MUSEUM OF VICTORIA

S 1002 –